ITS " COMPARE"

STRATEGIC DEPLOYMENT PLAN

FINAL REPORT

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ITS "COMPARE"
STRATEGIC DEPLOYMENT PLAN

FINAL REPORT

COMPARE

HAMPTON ROADS

Prepared for:

"COMPARE" Steering Committee

Prepared by:

I-95 Northeast Consultants (NEC)

October, 1995

ACKNOWLEDGMENT

This document is prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration, and the Virginia Department of Transportation. The Report is a result of the coordinated efforts of many individuals, groups, and government agencies. The work of the following individuals as the COMPARE Steering Committee for this project contributed immeasurably to the effectiveness of this project. The I-95 Northeast Consultants (NEC) prepared the document.

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LIST OF ACRONYMS

AAA: American Automobile Association
AHAR: Automated Highway Advisory Radio
ATIS: Advanced Traveler Information System
AT&T: Atlantic Telegraph and Telephone
AVI: Automatic Vehicle Identification
AVL: Automatic Vehicle Location

CAD: Computer-Aided Dispatch
CADD: Computer Drafting and Design
CATV: Cable TV
CBD: Central Business District
CBBT: Chesapeake Bay Bridge Tunnel Authority
CCIEN: Corridor Coalition Information Exchange Network
CCTV: Closed Circuit Television
CODEC: Coder/Encoder Unit
COMPARE: Congestion Management-A Regional Effort
CRT: Cathode Ray Tube
CV's: Commercial Vehicles
CVO: Commercial Vehicle Operations

DBMS: Database Management System
DERT: Downtown/Elizabeth River Tunnel Authority
D&S: Detection and Surveillance
DOW: Day-of-Week

EBB: Electronic Bulletin Board
EDP: Early Deployment Plan

FAX: Facsimile
FCC: Federal Communications Commission
FHWA: Federal Highway Administration
FM: Frequency Modulation

GIS: Geographic Information System
GIU: Gate Interface Unit
GPS: Global Positioning System
GUI: Graphical User Interface

HAR: Highway Advisory Radio
HAT: Highway Advisory Telephone
HRBT: Hampton Roads Bridge and Tunnel Authority
HOV: High-Occupancy Vehicle
HRCIM: Hampton Roads Centralized Information Management
HRPDC: Hampton Roads Planning District Commission

IEN: Information Exchange Network
ITS: Intelligent Transportation Systems

JCCT: James City County Transit

LAN: Local Area Network
LED: Light-Emitting Diode
LORAN: Long-Range Navigation System
LOS: Level of Service

MERT: Midtown/Elizabeth River Tunnel Authority
MMBT: Monitor-Merrimac Bridge and Tunnel Authority
MSA: Metropolitan Statistical Area

NCDOT: North Carolina Department of Transportation
NEC: I-95 Northeast Consultants

PC: Personal Computer
PCD: Personal Communication Device
PCS: Personal Computer System
PenTran: Peninsula Transportation District Commission

RF: Radio Frequency

SONET: Synchronous Optical Network
SOV: Single-Occupancy Vehicle
STIP: State Transportation Improvement Program
STP: Surface Transportation Program

TAR: Traveler Advisory Radio (same as HAR)
TAT: Traveler Advisory Telephone
TIP: Transportation Improvement Program
TMC: Traffic Management Center
TMS: Traffic Management System
TOC: Traffic Operations Center
TOD: Time-of-Day
TRS: Traffic Responsive System
TRT: Tidewater Transportation Transit Authority

USDOD: United States Department of Defense
USDOT: United States Department of Transportation

VAR: Value-Added Reseller
VBI: Vertical-Blanking Interval
VDOT: Virginia Department of Transportation

VIP: Video-Image Processing
VMS: Variable Message Signing
VPA: Virginia Port Authority
vsp: Virginia State Police

WAN: Wide-Area Network

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BACKGROUND

The COMPARE Project (Congestion Management Plan, A Regional Effort) in Virginia is the development of a Strategic Deployment Plan for Intelligent Transportation Systems (ITS) in the Hampton Roads Region of Virginia. The Region is an economically-vital and growing area; literally a crossroads of commerce and industry with a large number of tourists annually visiting the Region. The goals of the COMPARE project are to reduce congestion, improve mobility, safety and environmental quality in the Region. The Plan focuses on the strategic deployment and integration of advanced information and transportation systems and technology to more effectively utilize the Region's highway and transit systems.

One of the must immediate effects of this growth is increased traffic congestion and, with it, a general increase in the level of incidents, congestion and traveler frustration. The COMPARE Steering Committee consists of the Virginia Department of Transportation (VDOT), local jurisdictions, and transit agencies, in conjunction with the State Police, private transportation providers, the Viiginia Port Authority, the U.S. Naval Base, Old Dominion University, and the Hampton Roads Planning District Commission (HRPDC). Given limited transportation funds, the Committee set out to chart a path for a staged deployment of ITS technologies that responds to the Region's priorities for improved transportation system needs.

The Plan has therefore been oriented toward the development and deployment of transportation needs or User Services, as defined by transportation users in the Region. User Services are individual elements used by transportation service providers to support improved mobility, such as: en-route or pre-trip traveler information services, traffic control, and procedures aimed at better management of highway incidents. The basic approach in the development of the Plan was to define the Report's transportation needs in terms of Priority User Services, identify the corresponding system functions required to support the User Services and then to identity the appropriate technology and system configurations for achieving the required function in a cost-effective manner. The COMPARE study closely follows the model ITS Early Deployment Planning Process developed by the Federal Highway Administration (FHWA), while building on the ITS infrastructure already in place.

USER SERVICE NEEDS

Selection of User Services was based on identified transportation problems, policy issues, and the current and planned transportation infrastructure, as identified by existing and potential transportation users in the Region. The Priority User Services determined to address the Hampton Roads Regional transportation needs are:

Short Term

- En-Route Driver Information - Driver advisories and in-vehicle information to provide for informed traveler selection of route and mode for convenience and safety during travel.

- Incident Management - Rapid detection of traffic accidents and incidents and implementation of systems management responses to minimize delay and safety impacts.

- Pre-Trip Information - Traveler information for aiding key travel route and mode decisions in response to real-time or anticipated conditions.

- Centralized Information Management - Communication infrastructure and procedures to improve interagency coordination.

Medium-Term

- Emergency Vehicle Management - Fleet management and traffic control measures to reduce incident and emergency response times.

- Traffic Control - Integration of increasingly condition-responsive traffic control on streets and highways in the Region.

- Public Transportation Management - Automation of transit operations to improve efficiency and customer responsiveness.

Long-Term

- Commercial Vehicle Electronic Clearance - Automation of en-route regulatory procedures.

- Demand and Management Operations - Incentives to modify travel behavior toward more efficient mode and route choice impacts.

Each of the User Services is supported by the deployment of one or more basic technologies serving key functions such as: surveillance, communications (including inter-agency communications), information processing, individual traveler interface and traffic control. Detailed definition of the User Services Plan can be found in the Initiative 1 Report: COMPARE User Services.

REGIONAL ARCHITECTURE

To provide the general framework within which the ITS components and User Services are to be deployed, a regional "architecture" concept was developed. The architecture identifies the transportation functions to be performed in the Region, allocates these functions to systems and subsystems, and defines the flows of information and the interfaces between the subsystems and components. The Architecture is to be used to guide the design and staged implementation of ITS systems and technologies in the Region.

The recommended architecture is a hybrid-type: it is centralized from the view point of regional data sharing and coordination on regional matters, and is decentralized in the area of local traffic control autonomy. The architecture involves a three-level structure. The upper level consists of the Regional cooperative information-sharing Clearinghouse function, the middle level consists of the operations coordination performed for the individual VDOT facilities by the VDOT Traffic Management System Center, and the third level consists of the individual operating agencies, local governments or facilities. This approach is consistent with the open, inter-operable National Architecture being developed by U.S. Department of Transportation. A simplified version of the COMPARE System Architecture is found in Exhibit ES-l. The selection of the Regional architecture laid the groundwork for the development of the Strategic Deployment Plan.

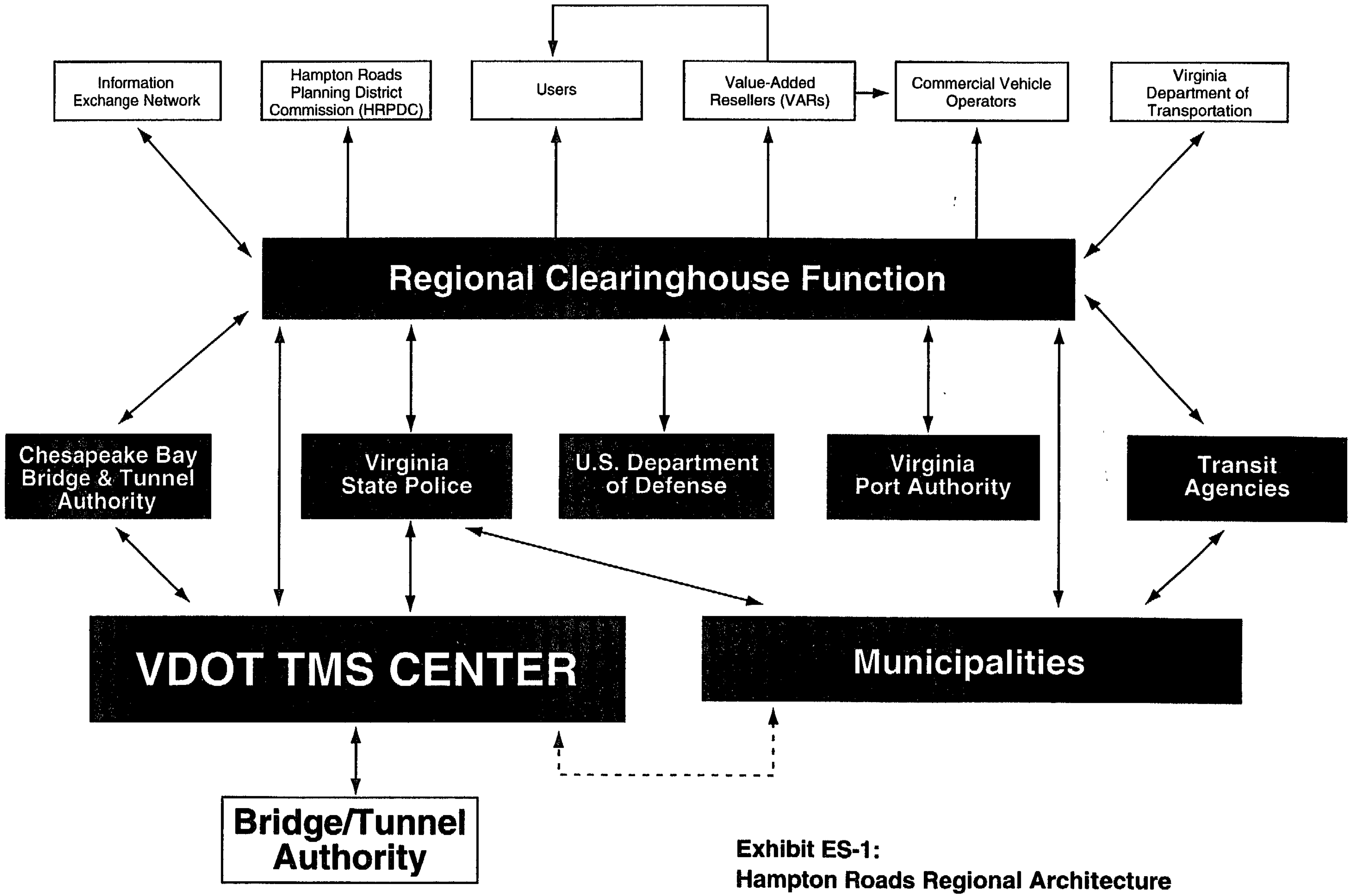

Exhibit ES-1:
Hampton Roads Regional Architecture

STRATEGIC DEPLOYMENT PLAN

Key objectives guided the development of the Strategic Deployment Plan for the Region. They included:

- To develop a Plan that targets the most immediate and beneficial improvements serving regional travelers, i.e., tourists and commuters. The target areas are the COMPARE Priority User Services (listed above).

- To develop common "core" functions which will support the provision of Priority User Services. Deployment of these functions provides a logical path toward development of a broad range of User Services and provides the most cost-effective means of deploying ITS.

- To establish a Regional System Architecture as the organizational framework for the Hampton Roads Region. This provides for seamless deployment of the required functions across jurisdictional boundaries.

- To build upon the installed and planned ITS components in the Hampton Roads Region as a point of departure to a staged deployment approach. The Plan expands current or planned ITS capabilities to fill in "gaps". The benefit to this approach is an early and visible "pay-off of ITS technologies to the Region's travelers.

The Strategic Deployment Plan is defined in terms of specific projects, the implementation of which provides the functions required for the Priority User Services. At the same time, this deployment establishes many of the "core" elements essential to jump-start the Regional ITS deployment.

Exhibit ES-2 presents the recommended COMPARE Implementation Plan. The plan is divided into two stages: Short-Term and Long-Term activities. The Short-Term activities (1 to 5 years to deploy) focus on the deployment of functions which support multiple User Services, provide a basis on which to provide future improvements and produce "early winners" to display visible and traveler-valued services. The Long-Term activities consist of the logical next steps; either geographic or functional extensions of the Short-Term activities and the provision of additional User Services. The Long-Term program builds on the basic functions provided in the Short-Term plan Given the dynamic nature of ITS concepts and technology, the SDP requires continuous updating during the 5 to 10 year, Long-Term activities period.

Detailed discussion of the recommended function deployment activities and their general order of implementation, estimated costs and related key issues is presented in the Initiative Report.

Exhibit ES-2
COMPARE Implementation Plan

Function	Short-Term Activities	Long-Term Activities
Surveillance	Coordinate Bridge and Tunnel Data (Hampton Roads Bridge/Tunnel, Monitor/Merrimac Bridge/Tunnel, James River Bridge, Coleman Bridge, Downtown and Midtown Tunnel) with VDOT/Regional Traffic Management System (TMS) -Software Development.	
	Extend Interstate VDOT Surveillance Systems along I-64, I-264, I-464, I-664, and Route 44.	
	Extend and Upgrade Arterial Surveillance System along the Identified Regional/Arterial Highway System.	Extend CCTV Coverage along Regional/Arterial Highway System (est. 10 sites/year). Extend Weather/ Environmental Sensor Coverage along Regional/Arterial (est. 4 sites/year) Highway System.
	Encourage Adoption of "#77" Cellular Call-In Program Regionwide.	Implement Automatic Vehicle Identification/Automatic Vehicle Location (AVI/AVL) Transit System for PenTran and TRT and AVL System for Emergency Vehicles Regionwide.
Communication	Provide Remote User Station Capability for Region's Transportation Agencies and Utilize Existing Fax/ Telephone/Modem%Mail Systems (Interim).	Provide Video Conferencing for Region's Transportation Agencies.
	Develop Communications Network Regionwide.	
	Develop Information Exchange Network.	Enhance Information Exchange Network and Expand to other Districts and Regions.
Information Processing	Develop Manual Input to Clearinghouse for Regional Data (Interim).	
	Expand MOT TMS to Meet Regional Architecture Needs	
	Upgrade and Automate VDOT/Regional TMS System.	
Traveler Interface Systems (TIS)	Implement Highway Advisory Radio (HAR) along the Interstate Regionwide and Upgrade to Automated HAR (AHAR).	
	Implement Interactive Kiosks at key Public Generators and Key Arterials To and Fmm the North Carolina Border Area.	Implement Interactive Kiosks at Other Major Generators .
	Implement Variable Message Signs (VMS) at Major Freeway-to-Freeway Points and Key Arterials To and From the North Carolina Border Area.	Implement VMS at Major Freeway Diversion Points and at Key Arterial Decision Points.
	Upgrade Phone-Based "1-800" Traveler Information System Regionwide.	
	Promote and Encourage Commercial TV Usage for Traveler Information Purposes.	

Exhibit ES-2
COMPARE Implementation Plan

Function	Short-Term Activities	Long-Term Activities
Traffic Control and Management	Expand Existing Signal Systems (includes adding signal system for Williamsburg) Regionwide.	Extend Signal Systems as New-Signals are Installed (est. 30 intersections/year) Regionwide.
	Expand Number of Signal Timing Plans and Traffic Responsive Feature for Signal Systems Regionwide.	
	Expand Emergency Vehicle Preemption Systems Regionwide.	Implement Regionwide Ramp Metering (Staged).
	Provide Signal Coordination/Cooperation Across Jurisdictional Boundaries Regionwide.	Provide Greater Signal Coordination Cooperation Across Jurisdictional/ Boundaries Regionwide.
	Implement Automated Incident Detection Algorithms at VDOT TMS for Interstates.	Implement Automated Incident Detection Algorithm for Regional Arterial Network at VDOT TMS.
	Computerize Incident Response Lists for Regionwide Applications.	
	Develop Computer-Aided Dispatch (CAD) System for Emergency Response of Highway Incidents Regionwide.	
	Automate Regional Traffic Diversion Plans	Implement Automated, Real-Time Traffic Diversion Algorithm at VDOT TMS.

EARLY ACTION PLAN

The short-term activities provided in the Implementation Plan (Exhibit ES-2) indicates the key early action projects. Early funding and implementation of these projects, particularly, development of the Regional surveillance and communications systems, will lay the groundwork for the traveler information and other ITS services supported by these projects.

Each of the COMPARE Members has a key role to play in the development and operation of ITS systems in the Hampton Roads Region. VDOT is developing their TMS Center through which to manage and coordinate operation along the Interstate system. At the same time, each local public agency will continue to be responsible for implementation and managing ITS-based systems for their respective transportation facilities and services. Effective regional operations will require real-time sharing of regionally-significant traffic and transportation condition information (congestion problems, incidents, construction and maintenance activities, transit schedules) among all transportation-related agencies in the Region.

To provide for the Regional transportation database and common dissemination among all transportation agencies in the Region, a "Clearinghouse" function is proposed. A Regional Operations Committee of key technical staff from participating agencies is also recommended to promote and manage coordination among the various transportation agencies and their systems and related Clearinghouse functions. The centralized database provided by the Clearinghouse function would also be available to private service providers, planning organizations and entities outside the Region.

A key challenge facing COMPARE will be the transition from "study' to implementation. Aggressive implementation requires that the COMPARE members develops a consensus on selection, funding, and implementation responsibilities for the early action project. To aid in this process, the COMPARE Technical Committee has formed three Task Forces:

- Institutional/Financial
- Public/Private Partnership
- Technical Systems Interface

The purposes of the Task Force are to undertake key "start up" actions. Key action items will include:

- Institutional/Financial issues
  - Formally establish the ITS Subcommittee of the HRPDC Technical Committee.
  - Secure coordinated representation from appropriate divisions of VDOT to ensure continuation of the COMPARE program.
  - Review priorities for budget implications.
  - Establish interim staff support (donated staff, rotating responsibility) for convening, agenda-setting and follow up.

- Technical Interface
  - Establish initial Regional Clearinghouse functional procedures.
  - Consider appropriate stages for establishing and upgrading an interagency communication network.
  - Complete current program of developing incident response protocols and diversion plans.
  - Determine procedure for cross-boundary/interjurisdictional coordination and common technology selection.

- Public/Private Partnerships

  - Consider public/private partnership potential for communications systems resource-sharing, value-added information service provision and other types of collaboration that may be pertinent to COMPARE.
  - Solicit private sector interest from media and service providers.
  - Review options for contractual arrangement with public-private partnerships.

The development and deployment of the ITS system is presumed to offer a major role for the private sector. Public/private partnerships can serve as the basis for the commercial provision of individual traveler information services augmenting information available through the Clearinghouse function. In addition, there are a range of collaborative opportunities for private entities to provide communication, installation, operation and maintenance services that can capitalize on private investment and resource sharing as well as private sector technical expertise and entrepreneurial experience. VDOT has established a legal and administrative program for such partnership in the Virginia Transportation Public-Private Transportation Act of 1995.

ACKNOWLEDGMENT

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1. INTRODUCTION AND BACKGROUND

This Report presents the ITS Strategic Deployment Plan and the associated Short-Term and Long-Term Implementation and Operations Plans (Tasks L, M, and N) for the Hampton Roads Region. The purpose of these plans is to guide the implementation of the ITS transportation management system and traveler information projects in the Region based on meeting the transportation goals of the Region.

The Report builds on the background analysis, surveys and User Service priorities developed in Initiative 1 and supports the Communications Systems recommendations conducted in Initiative 3 and the Advanced Traveler Information System recommendations of Initiative 4. Other background material includes the supporting Initiative 2 Task Reports covering functions, technologies and architecture. All Task Reports are listed in Appendix A. Maps displaying key features and recommendations for the Region are provided at the end of this report as Appendix C.

THE PROMISE OF INTELLIGENT TRANSPORTATION SYSTEMS

The Hampton Roads Region is an economically-vital and growing area; literally a crossroads of commerce, industry, and recreation. Since 1970, its economic base of shipping, shipbuilding, agriculture, and military infrastructure has been significantly enhanced by an influx of high-tech electronics firms, a growth in banking, and further development of its recreation and cultural resources.

Drawn by tbis positive economic environment, and also by the good climate and high quality of life, the Hampton Roads Region has seen an influx of new residents. The Norfolk-Newport News-Virginia Beach Metropolitan Statistical Area (MSA) has almost one and one-half million residents and encompasses three cities among the 100 largest cities in the United States. This area also is a recreational destination to over 2.5 million visitors per year.

As has been realized in many growing urban areas throughout the United States, one of the most immediate effects to be felt from this growth is increased traffic congestion with associated lower air quality levels, and a general increase in the level of incidents, congestion and traveler frustration. This affects not only the Region's residents, but also impacts visitors and their views on the attractiveness of the area. The Region, with the cooperation of the Virginia Department of Transportation (VDOT), has embarked on a steady program of increasing highway capacity through new construction and roadway widening. However, budget limitations, long lead times and the constraints associated with the impacts of new capacity have placed increasing emphasis on incorporating interjurisdictional traffic management and traveler information systems to manage and operate the existing transportation systems to their fullest efficiency. In addition, national air quality standards require that the Region develop a more systematic role for transportation improvements that are not oriented to increasing capacity for single occupant vehicles.

Advancement in computation, control and communications offer the combined potential of facilitating automation of traffic management and traveler information. Together with new institutional arrangements, these technologies can increase the effectiveness of systems status information which can be gathered, improve the management of roadways and transit facilities and increase the useful traffic condition information that can be communicated to travelers. Such systems promise to address not only the usual challenge of peak period congestion, but also faster response to problems caused by accidents and incidents, provision of advisories to travelers about alternative routes and modes, priority services to emergency vehicles, automation of regulation of interstate trucking and other service improvements. Many of these services can be introduced at modest costs and shorter time frames than conventional capital-intensive improvements.

Recognition of this potential has been embodied in the national Intelligent Transportation Systems (ITS) Program under the United States Department of Transportation (USDOT). The national ITS Program, in conjunction with the states, developed a mix of research, operational tests and programs to encourage deployment of projects at the state and local levels. This program collectively aims at improving all facets of highway and transit-related facility and systems operations and demand management.

ITS Early Deployment in the Hampton Roads Region - The COMPARE Program

VDOT has begun to undertake a series of comprehensive efforts focused on facilitating a deployment of ITS and other advanced traffic management and traveler information systems covering the metropolitan areas in the Virginia's urban crescent. The first of these efforts is the COngestion Management Plan: A Regional Effort (COMPARE), a program focused on the Hampton Roads Region developed in conjunction with a strong initiative from local jurisdictions, transit agencies, and the Hampton Roads Planning District Commission (HRPDC).

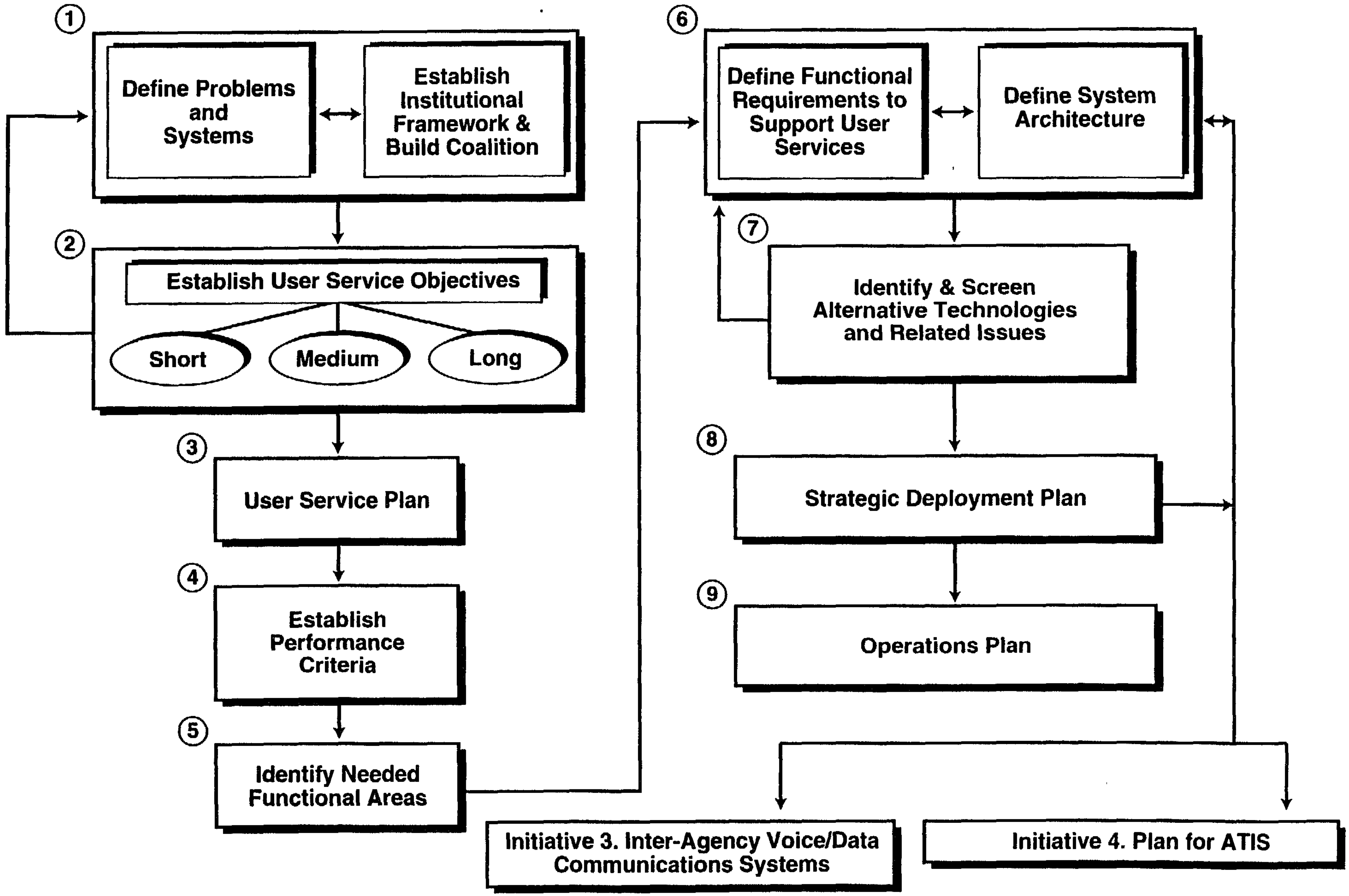
A total of 18 jurisdictions and agencies participate:

- City of Chesapeake
- Chesapeake Bay Bridge-Tunnel
- City of Hampton
- James City County
- James City County Transit
- City of Newport News
- City of Norfolk
- PenTran
- City of Portsmouth
- City of Suffolk
- Tidewater Regional Transit
- United States Navel Base (Norfolk Naval Air Station)
- City of Virginia Beach
- Virginia Department of Transportation
- Virginia State Police
- Virginia Port Authority
- Williamsburg
- York County

The COMPARE Project is the development of an Early Deployment Plan (EDP) for ITS. As illustrated in Exhibit 1, the EDP process, as developed by the Federal Highway Administration (FHWA), has been adapted by COMPARE to identify the Region's priority needs in terms of User Services. The EDP builds on efforts already under way and results in a Strategic Plan for deploying the system, technologies and organizational structure required to evolve this plan through the short, medium and long range. As appropriate to a joint multi-jurisdictional regional effort, the focus of the COMPARE EDP is on the identification of, and strategies for, transportation problems of a Regional nature. Regional transportation problems involve inter-regional travel including longer commutes (especially with bridges and tunnel crossings), traffic passing through the Region (both tourist and commercial) and long distance visitor (tourist-oriented) travel to the Region.

This report presents the Strategic Deployment Plan--including the Short-Term Implementation Plan and Operations Plan for implementing an ITS throughout the Hampton Roads Region over the next twenty (20) years. The Strategic Plan is defined herein in terms of the User Services and functions to be provided by the ITS network, the Regional architecture for implementing ITS-based systems, the supporting technologies and strategies required to perform the various functions, the approximate locations of the system components, the implementation priorities, and the associated costs. In essence, this Strategic Deployment Plan provides the overall framework by which budgets may be established and the regional transportation plan defined.

Exhibit 1. 'Compare' Planning Process



THE REGIONAL SETTING FOR ITS

Geography and System Control

Rivers, canals, and ocean influences have shaped the Hampton Roads area both geographically and economically. They have also influenced the development of the transportation system and its operational characteristics. As shown in Map 1 (included in Appendix C), the area is divided by geography into the Peninsula and Tidewater (or South Hampton Roads) areas including the participating jurisdictions. The roads shown in the figures are the upper level system oriented principally towards area-wide and inter-regional movement (National Highway System roadways and major arterials) together with other roadways, contained in the HRPDC's Congestion Management Study and identified as "deficient" by the Steering Committee.

This transportation network has a set of unique system characteristics. The network has highway "choke points" or bottlenecks due to a limited number of bridges and tunnels serving major river crossings, transit systems which are geographically segregated providing limited service between areas, and modal transfer points which are often the location of congestion and significant delays due to lack of convenient physical interchanges and facilities between travel modes.

Travel Demand and Level of Service

In addition to business district areas within the local jurisdictions, key generators of regional travel include several large military operation sites and substantial tourist and recreation-based attractions. The Hampton Roads Crossing Study indicates that the Peninsula region's population is projected to increase by approximately 40 percent by the year 2015 and the employment level is expected to increase from 202,000 in 1990 to 257,000 in the year 2015 (an increase of 27%). Military commuters make up a significant portion of the commuters traveling to work with over 125,000 military personnel and another 90,000 commuters employed by the defense industry in the Hampton Roads area.

Local travel is overlaid by four million visitor "through trips" each year to numerous destinations in Hampton Roads as well as North Carolina's Outer Banks. A range of summer and weekend recreation-oriented events generate special traffic impacts such as sporting venues, parades, concerts and festivals (such as Harborfest).

Goods movement in and through Hampton Roads reflects the Hampton Roads role as a major business port on the East Coast serving both regional commerce and national military logistics. The Hampton Roads Crossing Study indicates that cargo tonnage at port facilities and associated rail movements have nearly doubled since 1983. Goods movement in Hampton Roads moves over 30 million gross tons of freight per year as well as generating significant truck travel.

Map 2 indicates the current road operating conditions in Hampton Roads, as defined by level of service (LOS). It is not surprising to find the main regional routes such as I-64, together with the principal intraregional facilities such as Route 44, experiencing lower service levels, along with shorter more local and connecting links where network configuration and lane discontinuity are contributing factors.

Non-recurring congestion caused by incidents is also a major cause of congestion through disrupted flow and/or reduced effective capacity due to blockages. In the absence of better data, accidents provide a rough indication of the total number of incidents on a roadway as shown in Map 3. As indicated in the figures, many of the segments with rates above average tend to be those with higher traffic volumes.

The culmination of these conditions and situations results in key transportation deficiencies in the Region. With the planned growth for the Region, further deficiencies and greater levels of existing deficiencies can be expected. Expansion of transportation facilities represents one alternative and partial solution. Limited funds, environmental issues, and legal processes limit their effectiveness. As a result, ITS solutions provide a reasonable complement to these programs, while providing a solid foundation for future transportation enhancements.

2. STRATEGIC DEPLOYMENT APPROACH

REQUIREMENTS FOR IDENTIFICATION OF ITS STRATEGIC DEPLOYMENT PROJECTS

Goals of Strategic Deployment Plan

A set of key technical and institutional objectives, constraints and considerations associated with the deployment of ITS technologies were used in defining the Strategic Deployment Plan:

- Priority User Services. Initial deployment of the COMPARE program is targeted on the most immediate and beneficial impacts to regional travelers and those that are of common interest to all COMPARE members and has the widest area of coverage. These strategies are aimed at the Priority User Services: (1) En-Route Driver Information, (2) Incident Management, (3) Pre-Trip Traveler Information, (4) Centralized Information Management.

- Core Functions to Support User Services. An analysis of needed functions to support the Priority User Services indicated the potential to capitalize on common core functions and provide a logical path of development which allows for evolution of broader and better quality User Services. Cost-effective evolution of the required functions (such as surveillance, communications, data processing etc.) is necessary.

- Systems Architecture as Organizing Framework. Seamless deployment of the required functions is ensured through coordination among and compatibility between different control systems throughout the Region. This is based on a foundation of increased system data through expanded and improved roadway instrumentation regionwide.

- Installed Systems as Point of Departure to a Staged Approach. A significant portion of ITS infrastructure has been programmed for installation or is already operational. Expanding these capabilities to fill in "gaps" in terms of gathering and providing real-time information and traffic control capability and introducing the "core" functions on which the Priority User Services depend can (1) offer early visible pay off or (2) provide an "infrastructure" on which subsequent User Service projects will build.

In order to develop visible and beneficial wide-area projects for Early Deployment, consideration has also been given to those deployment issues which relate to the multiagency nature of COMPARE. These key institutional concern include:

- Regional Focus. With the large number of agencies involved in the Hampton Roads area's transportation operations, there is a diversity of agencies to whom ITS is expected to provide benefits. The nature of demonstrating the benefits of ITS are such that the improvements are designed to be inter-agency or regional in nature.

- Interagency Communications. Improved coordination and communication among the transportation agencies in the area through "clearinghouse" functions and early provisions of an information exchange network can develop support and maintain early success with the "regional" concept of the COMPARE program.

- Visibility and Leverage. From the standpoint of the traveler, the bulk of the investment into ITS over the next 20 years may go unnoticed if an improvement in traffic information quality and timeliness, as well as reduced delays, cannot be demonstrated and is not readily apparent in the near-Term.

- Clearinghouse for Regional Communication. The overall management and development of ITS policies and oversight of projects is to be handled through a consortium of local and regional agency representatives identified as the Regional Operations Committee. The roles of this Committee are to share ideas, to deal with procedural and policy matters regarding the management of the transportation network, and to further define the ongoing role of the Regional Clearinghouse.

- Maximum Opportunities for Public/Private Partnerships. To maximize the total ITS investment and to improve market-responsiveness, private entities should be given incentives to provide commercialized traveler information services and to expand their role in the development and operations of communications and other ITS facilities and services.

While many of these issues cannot be resolved in advance of deployment and operations experience, the deployment program and the associated architectural framework with its related clearinghouse activity should provide an effective platform for effective resolution of these institutional issues.

User Services

The EDP program is focused on the development and deployment of "User Services", i.e. the individual elements used by transportation service providers to support improved mobility. The basic approach in development of the Strategic Plan was to define the area's transportation needs in terms of Priority User Services, identify the corresponding system functions required to meet the User Services and then to identify the appropriate technologies and system configurations for achieving the required functions in a cost-effective manner.

User Services are based on either functional, technical or institutional commonalties. User Services serve as the building blocks of an efficient and user-responsive approach to deploying ITS. To date, thirty User Services have been defined within seven category "bundles" which have become a professional convention. An eighth "bundle" has been added -- Centralized Information Management – a User Service developed specifically for the Hampton Roads area. Each bundle shares common technical functions and therefore suggest efficient deployment approaches. The bundles and associated User Services, listed in Exhibit 2 are in various stages of maturity. Some of these services are available today, while others will require significant research and development as well as further advances in technology before they can be effectively deployed,

Exhibit 2. User Services

BUNDLES	USER SERVICES
kavel and Transportation Management	En-Route Driver InformationServices Route Guidance Traveler Services Information Traffic Control Incident Management Emissions Testing and Mitigation
kavel Demand Management	Pre-Trip Travel Information Ride Matching and Reservation Demand Management and Operations
Public Transportation Operations	Public Transportation Management En-Route Transit Information Personalized Public Transit Public Travel Security
Electronic Payment Services	Electronic Payment Services
Commercial Vehicle Operations	Commercial Vehicle Electronic Clearance Automated Roadside Safety Inspection On-Board Safety Monitoring Commercial Vehicle Administrative Processes Hazardous Material Incident Response Commercial Fleet Management
Emergency Management	Emergency Notification and Personal Security Emergency Vehicle Management
Advanced Vehicle Control end Safety Systems	Longitudinal Collision Avoidance Lateral Collision Avoidance Intersection Collision Avoidance Vision Enhancement for Crash Avoidance Safety Readiness Pre-Crash Restraint Deployment Automated Highway Systems Railroad Crossing Safety

COMPARE Priority User Services

To identify the appropriate focus for early deployment, a technical review and interview process were employed to identify and prioritize the various User Service needs for the Hampton Roads area. In addition, the User Service-related support functions themselves were separately evaluated for their ease of implementation and their potential for the Hampton Roads Area. Nine services were selected for the EDP, as defined in the Initiative 1 Report on User Services.

Four services were recommended for highest priority deployment in the short term. These User Services are:

- En-Route Driver Information
- Incident Management
- Pre-Trip Travel Information
- Centralized Information Management

The next three most important User Services identified were the medium term implementation services. A set of standards and concepts needs to be developed to allow the implementation to occur in a coordinated fashion. These User Services are:

- Emergency Vehicle Management
- Traffic Control
- Public Transportation Management

The remaining two User Services are recommended as longer term implementation services. The Commercial Vehicle Electronic Clearance User Service requires a state wide or multiple state implementation activity. The Demand and Management Operations User Service is currently being performed by the HRPDC. The results of the ITS deployment process is one element in that plan.

Priority User Services Descriptions

The User Services prioritized by COMPARE are described below:

1. En-Route Driver Information-Driver advisories and in vehicle information for **convenience and safety during travel**. En-Route Driver Information consists of providing travel-related information to drivers during their trip to improve traveler convenience and safety. Information is transmitted about traffic

conditions, incidents, construction, transit schedules, and weather conditions. This information may be used by personal, commercial, and public transit vehicle drivers. The information allows the driver to select the best route, or shift to another mode in mid-trip if desired. En-Route Driver Information may be provided through drivers advisories which are external to the vehicle (such as variable message signs or commercial radio broadcasts) or through the more advanced technology of in-vehicle signing. This provides the same types of information found on physical road signs today, directly in the vehicle. It can also include various levels of direct map displays or voice messages and other graphic displays. This User Service could be extended to include warnings of road conditions and advisories of safe speeds for specific types of vehicles.

2. Incident Management -- Quick identification of incidents and implementation of responses to minimize impacts. This User Service enhances existing capabilities for detecting incidents and taking the appropriate actions to respond to the incidents, Incident Management aids the transportation community by quickly and accurately identifying a variety of incidents through detection and surveillance of conditions and implementing responses which minimize the effects of those incidents on the movement of people and goods. This User Service also assists transportation officials in predicting traffic or highway conditions so action may be taken in advance to prevent potential incidents and/or to minimize their impacts.

3. Pre-Trip Travel Information -- Traveler information for aiding key travel decisions. Pre-Trip Travel Information is a User Service which provides real time system status and service information prior to departure which can be used by the traveler to affect several of his trip characteristics including mode, time of departure, route, destination. In general, Pre-Trip Travel Information is the means by which travel demand management strategies are communicated directly to the traveling public. It can have potential service improvements, economic development and environmental consequences. For example, tourists, commuters or truckers can be provided with information which may encourage them to make a trip at a time when they are less likely to encounter or contribute to congestion or to use alternatives to the single-occupant vehicle such as local or long-distance public transit.

4. Centralized Information Management -- Communication of preagreed upon information on an interagency basis. Centralized Information Management is the required communication infrastructure necessary to allow the various operating agencies to communicate and share information directly. This User Service is the essential voice/data communications system for interagency cooperation. A high quality system can reduce the conflicts between jurisdictions by coordinating operations, bringing together the different agencies and determining what each institutions' responsibilities will be, and then use the information network to link them together through a centralized management center. Communication links among jurisdictions must be capable of providing basic traffic management data among all interested jurisdictions (and potential private entities). Options include television cable, telephone lines, fiber-optic cable, AM and FM radio, cellular phone, beacons, and satellite transmissions.

5. **Emergency Vehicle Management -- Measures to reduce En-Route response time**. Emergency Vehicle Management is a User Service that reduces the time from the receipt of notification of an incident by a public safety answering point operator to the arrival of the emergency vehicles on the scene. It consists of three subservices: emergency vehicle fleet management, route guidance, and signal priority Fleet management improves the display of emergency vehicle locations and helps dispatchers send the units that can most quickly reach an incident site. Route guidance directs emergency vehicles to an incident location, while signal priority optimizes the traffic signal timing in an emergency vehicle's route. Primary users of this service include police, fire, and medical units,

6. **Traffic** Control -- Management of traffic on streets and highways. The Traffic Control User Service is an array of hardware (signals, signs and other control devices which communicate with drivers) backed by institutional, human, and software components to manage the movement of traffic on streets and highways. These provide for the integration and adaptive control of the freeway and surface street systems to improve the flow of traffic, give preference to transit and high occupancy vehicles, and minimize congestion while maximizing the movement of persons and goods. This User Service involves gathering of data from the transportation system, converting into usable information, and using it to decide on the optimum assignment of right-of-way to vehicles and pedestrians.

7. **Public Transportation Management -- Automa[redacted] of transit operations**. Public Transportation Management User Service provides improved information to the operators of public transit systems, automating various aspects of operations, planning, and management. The information provided to system operators will allow for more accurate and timely information on the status of the system, providing opportunities to improve the efficiency and safety of transit operations. Sharing of system status data through the Pre-Trip Travel and En-Route Driver Information User Services can indirectly benefit transit riders by permitting greater convenience of access to and use of the system.

8. **Commercial Ve**hicle Electronic Clearance -- Automation of En-Route Regulatory procedures Commercial Vehicle Electronic Clearance focuses on reducing operational interruptions (stops) associated with the necessary public regulation of commercial vehicles for routine weight, credential and safety checks. This User Service is designed to facilitate clearances across borders, thereby minimizing stops. Deployment of this User Service improves efficiency for private industry, by minimizing delays (and therefore operating costs) for those drivers/carriers whose credentials are current and whose vehicles meet regulatory safety standards. It also improves efficiency of enforcement efforts by allowing enforcement staff to focus on those drivers/vehicles with which deficiencies are more likely to be found.

9. **Demand and Management Operations -- Regulations** to reduce or modify travel impacts. The ITS User Service called Demand and Management Operations consists of technological activities in support of policies and regulations designed to mitigate the environmental and social impacts of traffic congestion through encouragement of increased efficiency of system or modal use. The Demand and Management Operations User Service includes the generation and

communication of management and control strategies such as HOV and ride-share matching through the use of advanced technology.

ITS Core Functions

Each of the User Services is supported by one or more technological elements or functions that produce a service such as surveillance, communication, and data processing. The range of potentially applicable technologies has, by convention, been grouped into a series of categories each of which may be facilitated by one or more specific technologies.

All services are supported by provision of several functions. For example, a sound program for incident management will depend on application of the following functions: detection, surveillance, stationary communications, variable message displays, and interagency coordination. These functions are defined in Exhibit 3.

Certain functions which support more than one User Service may be considered "core" functions. They provide the basis for cost-effective provision of ITS services and generally are the base pieces of the ITS system to be implemented. They are generic in that they support many if not all of the services deployed. Without the proper investment in core functions, the deployment of ITS will not function. Once the core functions are in place, the expansion of the system will be relatively simple. Sometimes a modest addition of a single new function to a "core infrastructure" can provide an entirely new User Service at relative low cost.

The "core elements" relevant to the regional focus of COMPARE include those that are considered essential to "model" traffic management and traveler information deployment by USDOT. These include the regional multimodal traveler information center concept implemented through the "clearinghouse" function described below, the incident management, freeway management and traffic signal control elements implemented through the surveillance and traffic control and management functions, and components of the transit management systems implemented through surveillance and information processing and traffic management functions.

Exhibit 3. Function Definitions

Function	Definition
Traffic Surveillance	Surveillance technologies that collect information about the status of the traffic stream. Possible technologies include loop detectors, infrared sensors, radar and microwave sensors, machine vision, aerial surveillance, closed circuit television, acoustic, in-pavement magnetic, and vehicle probes.
Vehicle Surveillance	Surveillance technologies that collect a variety of information about specific vehicles. These technologies include weigh-in-motion devices, vehicle identification, vehicle classification, and vehicle location.
Inter-Agency Coordination	Technologies that connect travel-related facilities to other agencies such as police, emergency services providers, weather forecasters and observers, and among Traffic Management Centers (TMC), transit operators, etc.
l-Way Mobile Communications	Any communication technology that transmits information to potentially mobile reception sites but cannot receive information back from those sites. Possible technologies providing this function include Highway Advisory Radio, FM subcarrier, spread spectrum, microwave, infrared, commercial broadcasts, and infrared or microwave beacons.
2-Way Mobile Communications	Any communication technology that transmits information to potentially mobile reception sites and allows receipt of information from those same sites. Possible technologies include cellular telephones, 2-way radio, spread spectrum, microwave, infrared, and 2-way satellite.
Stationary Communications	Any communication technology that connects stationary sites. Technologies include fiber optics, microwave, radio, land lines.
Individual Traveler Interface	Devices that provide information flow to a specific traveler. Technologies meeting tbis function include touch screens, keypads, graphics display and computer voices at kiosks; keypads, computer voice, and head-up displays in vehicles; personal communications devices carried with the traveler; and audiotex from any phone.
Payment Systems	Technologies that enable electronic fund transfer between the traveler and the service provider. The technology areas include Automated Vehicle Identification (AVI), smart cards, and electronic funds management systems. This function overlaps with the Electronic Payment User Service.

Exhibit 3. Function Definitions

Function	Definition
Variable Message Displays	Technologies that allow centrally controlled messages to be displayed or announced audibly to multiple users at a common location such as a roadside display or display board in a transit terminal. These technologies would typically be applied to provide information on highway conditions, traffic restrictions, and transit status.
Signalized Traffic Control	Technologies that allow for real-time control of traffic flow. Possible technologies include optimized traffic signals, ramp metering, reversible lane designation, and ramp/lane closures.
Restrictions Traffic Control	Operational techniques that restrict the use of roadways according to regional goals. Techniques include HOV restrictions, parking restrictions, and road use (congestion) pricing.
Navigation	Technologies that determine vehicle position in real time. Technologies that provide this function include GPS, LORAN, dead reckoning, localized beacons, map database matching, and cellular triangulation.
Database Processing	Technologies that manipulate and configure or format transportation-relatd data for sharing on various platforms. General purpose database software currently exists and is currently being adapted to transportation needs such as data fusion, maps, and travel services.
Traffic Prediction Data **Processing**	Data processing relating to prediction of future traffic situations. Algorithms under development include areas such as real-time traffic prediction, and traffic assignment.
Traffic Control Data Processing	Data processing related to the real-tune control of traffic. Algorithms under development include optimal control and incident detection, and the interaction of route selection and traffic control.
Routing Data Processing	Data processing related to routing of vehicles including the generation of step-by-step driving instructions to a specified destination. Algorithms under development include the scheduling of drivers, vehicles, and cargo; route selection; commercial vehicle screening, and route guidance.
In-Vehicle Sensors/Devices	Technologies providing a range of sensing functions to be located within vehicles. Functions addressed by these technologies include monitoring of vehicle performance and driver performance; determination of vehicle position relative to the roadway, other vehicles, and obstacles; improvement of vision in adverse conditions; and on-board security monitoring.

Communication forms the backbone of the system. It serves the function of transmitting or exchanging information, the life line of any real-time information system. Every ITS project will require the implementation of the communications backbone as its basis. The COMPARE EDP has been developed with a strategy that capitalizes on the efficiencies offered by the core function concept.

Each of the COMPARE Priority User Services was analyzed to identify candidate enabling functions and associated technologies. This analysis was based on a wide range of technologies capable of supporting robust, fully-functioned User Service implementations. In order to keep the number of technologies at a manageable level, they were grouped into functional areas. Ingeneral, each functional area is comprised of one or more separate technologies which can be used interchangeably in system deployment that provides a User Service. For example, two-way mobile communications could be provided by either digital cellular telephones or two-way satellite communications. The functional areas of surveillance, communications (including inter-agency communications), data processing, and control strategies were defined as the primary, applicable functions.

Exhibit 4 defines the associated system functions for the Priority User Services. Implementation of the technologies and systems required to support these functions will, in effect, implement the Priority User Services. The Strategic Deployment Plan is therefore organized around the efficient implementation of these needed functions. These functions have been further grouped into global functions for use in describing the Strategic Deployment Plan. These groupings are shown in the exhibit.

POINT-OF-DEPARTURE: EXISTING AND COMMITTED ITS PROJECTS

ITS projects in the Hampton Roads Region have been underway over the last several years. Several ITS elements are currently being used in the Hampton Roads area, including roadway surveillance/ detection applications, closed circuit television (CCTV), highway advisory radio (HAR), and variable message signs (VMS). This section describes these elements in general by jurisdiction or agency.

Exhibit 4
Functional Relationships Among User Services

User Services	Applicable Functions: Surveillance: Traffic Surveillance	Surveillance: Vehicle Surveillance	Surveillance: In-Vehicle Sensors/Devices	Communication: Stationary Communications	Communication: 1-Way Mobile Communications	Communication: 2-Way Mobile Communications	Communication: Inter-Agency Coordination	Information Processing: Data Base Processing	Information Processing: Traffic Control Data Processing	Information Processing: Traffic Prediction Data Processing	Information Processing: Routing Data Processing	Traveler Interface: Individual Traveler Interface	Traveler Interface: Variable Message Displays	Traveler Interface: Navigation	Traffic Control: Signalized Traffic Control	Traffic Control: Restrictions Traffic Control
1. En-Route Driver Information	●			●	●	●	●	●		●	●	●	●	●		
2. Incident Management	●			●	●	●	●	●	●	●			●	●	●	
3. Pre-Trip Travel Information	●			●		●	●	●		●	●	●	●	●		●
4. Centralized Information Management	●			●	●	●	●	●	●	●	●	●	●	●	●	●
5. Emergency Vehicle Management	●	●		●	●	●	●	●		●	●		●	●	●	
6. Traffic Control	●			●			●	●	●	●			●		●	
7. Public Transportation Management	●	●	●	●	●	●	●	●		●	●	●	●	●	●	
8. Demand & Management Operations		●		●	●			●				●	●	●	●	●
9. Commercial Vehicle Electronic Clearance		●		●	●	●		●				●	●			

Hampton Roads Bridge and Tunnel Authorities

The Hampton Roads area is characterized by several bridges and tunnels that have been early users of ITS technology. They include:

- The Monitor-Merrimac Memorial Bridge Tunnel contains an extensive roadway surveillance/detection system with loop detection and CCTV monitoring at key locations. This is combined with VMS to display roadway information or to direct traffic during construction, maintenance, or closure activities.

- The Hampton Roads Bridge-Tunnel contains an extensive roadway surveillance/ detection system with loop detection and CCTV monitoring at key locations. VMS units serve as variable speed limit signs and fixed display instruction relays. HAR is also in place along I-64 prior to the northern and southern bridge-tunnel approaches. Additional VMS units, upgraded displays and further HAR installations are also being planned in advance of the tunnel entry. A communication inter-tie with other bridge-tunnel centers in the area is proposed.

- The Chesapeake Bay Bridge-Tunnel is planning a comprehensive roadway detection and surveillance system including loops, CCTV, upgraded VMS and an initial HAR installation. Current technology includes motorist call boxes stationed every half mile along the bridge and six permanent VMS (plus two portable units) in the bridge area.

- The Downtown and Midtown Tunnels contain varying levels of CCTV, advance VMS, and loop detection to aid in monitoring the facility and detecting and responding to incidents in the tunnel areas.

- The James River Bridge contains an extensive roadway detection and surveillance system with CCTV monitoring and VMS at key locations along the bridge.

- The Coleman Bridge currently has one HAR location on the north side of the bridge with detection surveillance and motorist information (e.g., VMS) installations planned.

Virginia Department of Transportation (VDOT)

Several ITS Programs by VDOT are underway or existing within the Hampton Roads area. Roadway surveillance stations are strategically located (or planned) along the Region 's Interstate system including loop detection, vehicular class detection spacing, and CCTV monitoring to collect volume and occupancy information on, and visual surveillance of the interstate system and along Route 44. Currently, a VDOT Traffic Management System (TMS)

Center is being completed. This Center, when functional, is planned to serve as VDOT's Traffic Operations Center for the region. The Center will use the surveillance data collected along the Interstate and Route 44 for traffic management and traveler information system purposes. Access to this data is also planned for remote users to the system (local agencies, private parties, etc.) through electronic means, relaying data and near "real-time" graphical depictions of the transportation system.

Traveler information advisories from VDOT sources are currently delivered to the motoring public through the use of three primary information dissemination interfaces. These include:

- HAR -- Eight HAR transmitters broadcasting in the Hampton Roads area to advise travelers of traffic conditions. Plans are to upgrade this system to regionwide coverage in the near future.
- VMS - VDOT currently uses approximately 20 portable and 39 permanent VMS units located throughout the Region (primarily at bridge/tunnel areas) to alert drivers of upcoming traffic conditions.
- -800 Services - Currently, VDOT operates and maintains a l-800 service which is available to callers within Virginia providing taped messages on current traffic conditions on the area's major transportation corridors, as well as for each bridge and/or tunnel.

Transit Agencies

The Tidewater Regional Transit (TRT) Authority (covering the southern Hampton Roads Region) has used a sign post Automatic Vehicle Location (AVL) system (with limited capabilities) at several selected points along its routes to assist in transit vehicle locating.

Cities

Many of the cities in the Hampton Roads area have limited means for data collection, data processing, and information dissemination of roadway and traffic information. There are, however, several cities (e.g., Newport News, Norfolk) which have fairly extensive surveillance systems that use inductive loop detectors to collect volume and occupancy data. These data are currently being used to support the cities' arterial closed-loop traffic control systems and, at this point, have basic ITS application.

Military Facilities

The Norfolk Naval Air Station has several VMS units on its grounds. These VMS units are used primarily to alert employees of road or gate closures within the facility. The VMS system does not receive input from data collection or information processing systems external to the Naval yards (except from public radio and TV reports). They primarily regulate and control localized conditions.

Private Sector

Currently Metro Traffic monitors, collects, processes, and transmits traffic conditions and information on the Hampton Roads area's roadway network to 27 radio and three TV stations in exchange for air time (which it sells to commercial vendors). This data is collected from airplane surveillance and may be supplemented from VDOT, the police, and private callers. Metro Traffic's roadway information covers all of the Hampton Roads area, including bridges, tunnels, Interstates, major and minor arterials, and railroad crossings. This data is distributed to the radio and TV stations on a regular basis during peak hours and on an event-basis during non-peak hours.

REGIONAL ARCHITECTURE

One of the primary elements of an ITS Strategic Plan is the system architecture. In the context of ITS, an "architecture" describes what a system does and how it does it, providing the general framework within which the various system components are deployed. It identifies the functions to be performed by the system, allocates these functions to subsystems, and defines the flows of information and the interfaces between the subsystems and components. In Hampton Roads, the roadway network is managed and operated by several autonomous entities with additional agencies responsible for transit (PenTran and TRT) and enforcement (Virginia State Police). Each agency is autonomous to its own area and operations. While this operation allows each area to control its functions and service levels, little interaction between entities on a regional basis exists. A regional architecture -- identifying the various transportation management systems and the appropriate linkages between these systems -- is necessary to provide a "seamless" transportation network from the perspective of the traveler and to provide uniform regional communication among all COMPARE participants.

Architecture Considerations

Defining regional ITS architecture requires an understanding of the User Services and functions to be provided by the ITS network. The institutional framework and constraints in which the ITS-based system must function, technology availability, and the relationship between the public and private sector is also necessary. As described in the Task Report on Regional Architecture, these considerations include:

- Institutional Framework: An ITS architecture -- particularly on the regional level -- must fit within the existing organizational infrastructure. The architecture must build logical extensions to the existing framework, providing for a seamless transportation network while respecting local autonomy.

- Functional Areas: The development of a regional ITS architecture is primarily based on functional elements in systematic relationships which capitalize on the significant overlap among functional areas and core features.

- Architectural Compatibility: The system architecture must be flexible such that it is able to simultaneously integrate the existing ITS "islands" of technology into the proposed future system while being open to incorporation of new and evolving technologies consistent with standards and other key features of the National System Architecture being developed by USDOT.

- Public/Private Responsibilities The ITS architecture must preserve the option for a wide range of allocation of responsibilities among public agencies and private entities.

Assessment of Alternative Configurations

Given the above considerations, a range of architectural configurations was considered including both centralized and decentralized approaches. Based upon an assessment of each alternative's ability to meet the COMPARE Region's transportation objectives, while considering the identified system constraints and sensitivity issues, a "hybrid" architecture was recommended. Combining both distributed and centralized features custom-tailored to the Region reflects the importance of strong cooperation among the local jurisdictions/ agencies. The distributed elements of this approach allow the autonomy needed for localities to effectively operate their own systems. All command and control functions remain at the individual agencies. Yet, the centralized elements of the hybrid approach also provide the data and information sharing and inter-agency coordination/cooperation functions necessary to meet transportation needs on a regionwide basis. The concept also provides a single regional interface to encourage the future participation of private ITS service providers (e.g., ATIS, CVO), and to serve as a contact for external ITS entities such as the I-95 Corridor Coalition Information Exchange Network (CC IEN) and the VDOT Emergency Operations Center in Richmond.

Recommended Architecture

The recommended architecture is conceptualized in Exhibit 5. The boxes represent the agency specific transportation systems, or independently operated transportation facilities. The lines which connect the boxes represent the directional data flows between these systems and/or facilities. The exhibits inside the boxes list the functions performed at a system or facility. Data flow types are identified along the lines. For clarity, the municipalities are grouped together, since they perform similar functions within their relative jurisdictions.

The architecture involves a three-level structure. The upper level consists of the information-sharing Clearinghouse, the middle level consists of the operations coordination performed for the individual VDOT facilities by the TMS Center, and the third level consists of the individual operating agencies, local governments or facilities, which maintain control and management responsibility. The architecture also supports agency-to-agency data sharing independent of the Clearinghouse.

The importance of core functions can be seen in the fact that the functions and data flows to provide the En-Route Driver Information User Service (the highest priority item per User Services Plan adopted earlier) establishes the essential architectural relationships. Additional User Services are provided with the same three level structure, only the required functions and data flows change.

The essential backbone of the regional architecture will be an information exchange network (IEN) providing the communication backbone of COMPARE. An IEN may select or obtain information from each jurisdiction's systems, distribute data as previously agreed and allow each agency to review and communicate around the data. Starting with a simple electronic bulletin board, the IEN is envisaged to evolve into a user-friendly semi-automated means of providing common communication format with a range of information functions.

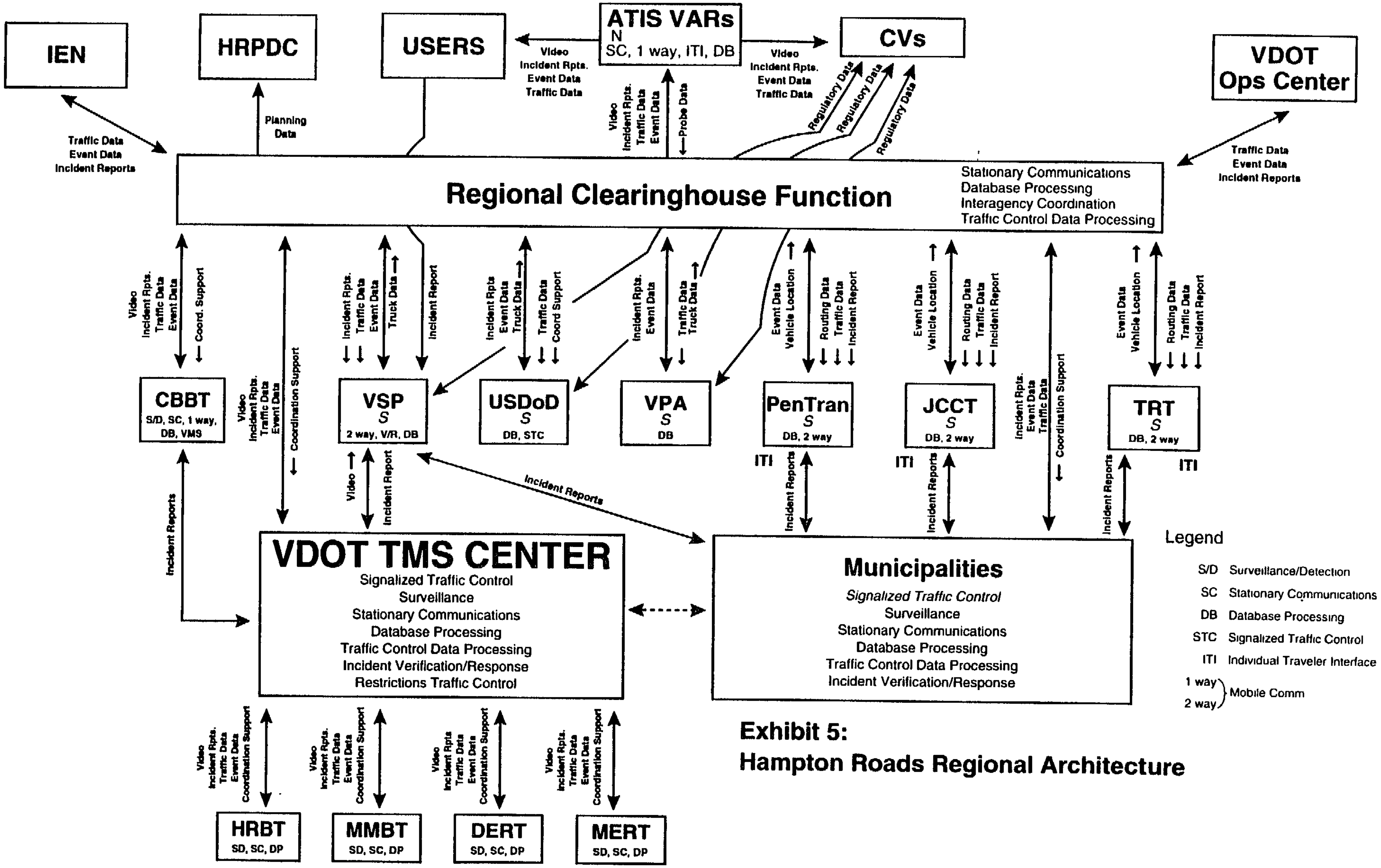


Exhibit 5:
Hampton Roads Regional Architecture

For the Hampton Roads Region, the proposed architecture achieves a number of useful purposes. Local autonomy of key areas is maintained. A major portion of the regional architecture design is in place or planned for implementation shortly through VDOT's TMS Center. Information will be supplied (two-way) on a regional basis. Many of the regional functions can be staged for implementation or can be easily expanded onto local TOCs to limit financial constraints. Finally, using the central coordination, more effective and coordinated involvement of the private sector can be accomplished. The result will be a defined, coordinated plan for ITS activities for the Hampton Roads Region.

Regional Clearinghouse Function

The Clearinghouse is a functional concept -- not a "place". The Clearinghouse function concept refers to the specific regional ITS functions desired in common by all members of COMPARE. It is important to recognize that the functions of the Clearinghouse concept are limited to actions requiring interjurisdictional response or benefiting from interjurisdictional cooperation – and do not replace the operations and management responsibilities of individual COMPARE participating agencies. These common functions include sharing real-time and static information on transportation conditions (e.g., speeds, travel times, transit schedules, incidents, congestion problems, construction and maintenance activities) within the Hampton Roads area that may affect regional or interjurisdictional travel. The Clearinghouse function can integrate this information into a regional database of traveler information, covering all modes and routes. In this manner, the Clearinghouse concept can provide each agency with a single point of contact for disseminating information to the other agencies and private concerns, as well as a single distribution point from which an agency can obtain current information on the transportation network beyond its jurisdictional boundaries.

Another primary function of the Clearinghouse concept can be to promote and manage coordination between the various transportation agencies and their systems. An example of this is: coordinating planning and construction or maintenance activities such that corridor capacity on parallel routes or modes is not significantly reduced. Examples are: using one agency's detection to describe conditions or problems on another agencies' facilities, coordination of system operational parameters (e.g., signal timing plan) across jurisdictional boundaries in response to an incident, and sharing of incident management resources.

A significant issue that will be associated with the Strategic Plan is defining the level of coordination between the agency-specific TOCs, and the corresponding role of the Regional Clearinghouse function. Most transportation problems can be predicted -- at least in terms of what may happen and where; although not when -- and the corresponding regional strategies and agency-specific responses to these problems can be prearranged, pre-approved, and documented. The function of the Clearinghouse concept will be to implement and monitor these preplanned regionwide responses.

The Clearinghouse function also serves as an interface between ITS's within the Region and those ITS's outside of the area. The I-95 Corridor Coalition's activities include an information exchange network, development of standard operating procedures for notification of incidents and construction/maintenance activities having multi-member impacts, feasibility of regional communication centers, and commercial vehicle operations (e.g., standardized permitting). It is important to note that the Clearinghouse concept has been defmed by its function. This function is independent of where the Clearinghouse is physically housed within the Hampton Roads Region. The current recommendation is to have the VDOT TMS operate and maintain the Regional Clearinghouse functions, thereby expanding its planned capabilities and covering a more extensive transportation system. Long-Term future needs may necessitate the implementation of a separate facility as the Regional Operations Center.

Regional Operations Committee

Rather than create a new bureaucracy, the Clearinghouse function can be administered by a coalition of the Hampton Roads agencies building on the existing relationships formed within the HRPDC and the COMPARE Project. A Regional Operations Committee (ROC) may be comprised of representatives which evolves from and overlaps with the current COMPARE Steering Committee. ROC representatives should consist primarily of senior operations staff members from each agency involved in or affected by the regional architecture. The ROC members may also include members of the HRPDC Technical Committee subcommittee on ITS, not already represented on the ROC. This Committee would meet on a regular basis (e.g., monthly) to share ideas, address procedural and policy matters regarding management of the transportation network, and to defme the ongoing role of the Clearinghouse function. The Operations Committee meetings might be coincident with the HRPDC ITS subcommittee meetings.

A team should be responsible for initiating and then managing pre-planned and pre-approved roles within a wide variety of incident response plans within the Region. The development of these response plans can be the responsibility of the Operations Committee. Each response plan would include as a minimum:

- Roles and responsibilities of each agency in the Clearinghouse function.
- Traveler information to be disseminated (e.g., VMS messages, media/private interface).
- Equipment and resources to be provided by each agency, and the personnel to be contacted.
- Diversion planning (e.g., defining alternate routes and preparing maps, signal timings and ramp meter rates, guideline for implementing diversion).
- Guidelines for implementing the response plan by the Clearinghouse.

The Operations Committee would also perform debriefings following major incidents, and modify the corresponding response plans as required. The Committee would also develop guidelines for Clearinghouse functions and operations when no plan exists for a particular problem and response must be developed "on the fly."

Role of VDOT TMS Center

VDOT plans for its Traffic Management System (TMS) to coordinate operations and share information among the various independently operated VDOT facilities. Therefore, it is recommended that the TMS initially serve as the interface between the VDOT facilities and the other transportation-related agencies in the region. Long-Term plans may result in the need for a separate Regional Operations Center. However, under the proposed plan, the VDOT TMS Center will meet that function and other planned expansions for the Region's needs.

The VDOT plan for the TMS also includes much of the "centralized" component of the recommended architecture (i.e., the functions that have been identified for the Clearinghouse). Under VDOTs current plan, the following capabilities are planned for sharing information with other jurisdictions and agencies:

- Graphic displays showing incidents, traffic conditions, and the status of equipment.

- A video image from a selected camera or a sequence of images from a series of cameras.

- Text reports of real-time transportation conditions.

- An electronic bulletin board system (E-mail).

Remote users (public and private) could utilize PC's equipped with modems to access these functions, limited by user type and needs. In addition, a central database of regional traffic information (both static and dynamic) is planned.

Much of the information of interest to participants in the Region would be focused in the VDOT TMS since state entities operate the major regional facilities. Furthermore, it is expected that during peak periods and major incidents, Virginia State Police will also be present in the TMS coordinating their responsibility for on-site incident management and dispatch of emergency vehicles on VDOT facilities. This focus suggest that the TMS would be a logical place to house the clearinghouse functions.

Role of Local Agencies

The architecture has a "distributed" component in that each public agency will continue to be responsible for implementing and managing ITS-based systems for their respective transportation networks. All command and control functions will continue to reside at the local level. Each of the agency-specific systems currently maintain a separate control or operations center, communications desk, or dispatch facilities which may be linked as part of the Regional Clearinghouse function.

The communications link to the Regional Clearinghouse (i.e., the Centralized Information Management function) will allow each agency to feed local information into and to receive regional information from the regional database. In addition, the architecture will support agency-to-agency communications independent of the regional database. This communication may support operational coordination between adjacent municipalities or other localized needs.

Role of Private Entities

Effective implementation of ITS in the Hampton Roads Region can be enhanced by encouraging new roles for the private sector. Private entities can provide investment capital, resource-sharing potential, special technical expertise and entrepreneurial experience in the provision of market-responsive services. Potential areas for new forms of public and private partnership include:

- Design, installation, operations, and maintenance of facilities and services on a turnkey basis.
- Marketing and sales of in-vehicle and portable devices to provide real-time traveler information and routing.
- The government agency providing access to the highway right-of-way to a private communications firm, in return for which the private entity installs and maintains a communications network (e.g., conduit, cable, and electronics) for the government agency's ITS network The private communications firm recoups the cost of-the communications system by sizing it to provide telecommunications services to other users (e.g., other private entities) and charging for the service.
- Collection, marketing, and sales of real-time traveler information.

The regional architecture, identified in Exhibit 5 for the Hampton Roads Region displays the relationships between the public and private sectors, along with their potential roles in data/information reselling.

Starting with its Public/Private Workshop and building on VDOT's commitment to partnerships, COMPARE has emphasized a commitment to public/private partnerships, and the respective roles of each in implementation, operation, and maintenance. In general, the various transportation management and enforcement agencies are responsible for collecting and integrating area-wide surveillance information (e.g., detectors) and then developing and implementing control strategies (e.g., incident detection and response, signal/ramp timing) based on this information. In the planned regional architecture, the private sector will play a role in the overall ITS plan for the Hampton Road area. A primary role of the private sector will be to analyze the integrated data, tailoring the information to meet the unique requirements of the end users (i.e., a "value added"); and then to market and disseminate the traveler information via radio and TV outlets, kiosks located at large travel generators, highway advisory telephone, and in-vehicle devices. There may be some exceptions to this general rule. For example, the public side may be installing and operating variable message signs and information kiosks at key locations throughout the roadway and transit networks to provide traveler information. Moreover, public-private partnerships may also be utilized to provide communications, incident response, service patrols and operational support.

While the development of specific collaborative relationships with private entities must evolve as the public information base improves and as the information exchange network develops, the role of the private sector must be explicitly accommodated and encouraged if true collaboration is to evolve.

USER SERVICE PROVISION THROUGH ITS FUNCTIONAL DEPLOYMENTS

In the Deployment Plan, the Priority User Services are improved or provided by means of specific projects that meet the functions which support the provision of one or more User Service through development and installation of hardware, software and related institutional procedures. The Strategic Deployment Plan has been developed using a strategy that builds up the "core" functions that support several User Services and adds the unique functions that provide additional services at relatively modest investments. Building on the existing state of deployment, the provision of functions are staged in short and long-Term phases designed to provide visible and valuable service improvements at the end of each stage.

While several of key functions exist (e.g., where VDOT and bridge and tunnel agencies are providing localized traffic management), many of the functions must be geographically expanded to a larger areawide basis to fully serve the targeted users (local commuters, external visitors, through trip makers). While the Strategic Deployment Plan expands some functions to a region-wide level (e.g., communications), others require implementation enhancement at specific locations in which improved information is needed (e.g., surveillance at all potential bottlenecks).

A key characteristic of the traveler information-oriented User Services is that once the required data collection/processing related functions are deployed, there is the potential to add various types of dissemination functions based on different media (VMS, HAR, Kiosk, telephone or modem dial-up) targeted at different types of travelers (commuters, visitors) and travel decisions (regional, local) at different points in the Region.

Several of the functions deployed to support traveler information-oriented services are also "core" functions for the provision of operations and management services as they require the same wide-area traffic conditions knowledge (e.g., emergency vehicle management and public transportation management). As a result, with relatively little modification, several of the other services below can be "piggy-backed" on these functions.

Several of the services are dependent on the plans of VDOT's TMS Center to centralize the hardware and software necessary for the data processing function and on the clearinghouse activity to support the interagency communications and coordination.

In the material below, strategic considerations are outlined in terms of the key functions associated with each priority User Service in the short and long term.

Priority 1 - En-Route Driver Information

An effective En-Route Driver Information service requires a large number of functions to collect, process and communicate information at a level of reliable, real-time quality to regional travelers. The needed infrastructure burdens short-Term implementation for deployment of the service. Functions to support this User Service include:

- Traffic surveillance to collect information about traffic conditions.
- Data base processing and traffic prediction data processing to convert data to types of information directly usable by travelers in their decision-making.
- Stationary communications to connect field devices to traffic operations centers.
- Variable message displays and one-way mobile communication are the basis for roadside communication with drivers focusing on advanced warnings with such elements as HAR and VMS.
- Interagency coordination is essential to all User Services since information interchange is essential to comprehensive conditions knowledge.
- Individual traveler interface such as ordinary dial-up telephone, perhaps with automated menu-driven audiotext. Traffic information is a key function for early warning to regional visitors and long-distance commuters.
- Two-way mobile communications based on commercial personal or in-vehicle communications devices and navigation technology providing position and routing information may evolve in subsequent stages as public/private collaboration potential develop.

The En-Route User Service has two key features: extending the service geographically on a selected basis and upgrading the advisories through a combination of improvements to the surveillance, processing and communications-related functions.

Priority 2 - Incident Management

Incident Management requires many of the same functions which support En-Route and Pre-Trip Information. However, since incidents are substantially concentrated in high volume or problem geometric areas, the deployment of support functions is more geographically concentrated in key corridors or choke points such as interchanges, bridge or tunnel approaches, etc. At the same time, the specific type of analysis is oriented towards reducing detection and response and therefore will place a greater premium on full automation of key functions through upgrading of both hardware and software. The key functions include:

- Traffic surveillance data is needed at a finer grain for incident management including greater emphasis on surveillance for verification and incident response (including emergency vehicle management).
- Data base processing and traffic prediction data processing focuses on incident detection and characterization to aid in the response process through implementing specific response strategies and traffic control (signal, HOV lane access) strategies.
- Stationary communications to connect field devices to traffic operations centers.
- Variable message displays and one-way mobile communications are the basis for advisories to approaching drivers through such elements as HAR and VMS and other potential traveler information services.
- Interagency coordination is essential to incident management since incident response involves state police, emergency medical services and local government elements.
- Two-way mobile communications supporting individual traveler interface based on commercial personal or in-vehicle communications devices (such as a cell phone or other potential traveler information service) can play a central role in incident detection.

Priority 3 - Pre-Trip Traveler Information

Providing intermodal information to commuters, visitors or through trip travelers prior to the actual trip builds on the same basic set of functions supporting En-Route Driver Information but without requiring the one-way mobile communication function of roadside devices. However, greater demands are made on both traffic surveillance which must provide data about all modes and on data base processing and traffic predicti[illegible]ta processing. Pre-

Trip Traveler Information requires trip timing and routing advisories dependent on the prediction of future conditions based on a combination of historical and current data together with the appropriate analysis functions.

Unlike other User Services, this tends to be more market-segmented since the type of information required by commuters vs. tbrough trip makers or visitors is different. As a result, the service will make use of a broader range of traveler interface technologies, As in the case of En-Route Driver Information, a valuable service can be provided at various levels of improved information.

Priority 4 - Centralized Information Management

This User Service is provided through the establishment of the Clearinghouse function, capitalizing on the VDOT TMS and use of the regional architecture to provide an agreed-upon basis for the organized sharing of information and coordination of common activities described above. The functions in the Deployment Plan that support this service include all of those involved with information that is to be shared in the three User Services above plus that required for ~~traffic control data processing~~ and signalized traffic control. Other aspects of this service are added through the architecture - guided deployment of interagency communications and the approach to information processing.

Priority 5 - Emergency Vehicle Management

Emergency Vehicle Management focuses signalized traffic control on key routes and adds the vehicle surveillance function together with a CAD-based routing data processing for dispatch of emergency vehicles. The geographic focus of the signalized traffic control function is generally limited to specific corridors operationally significant to emergency medical and fire and police vehicles. The CAD-based routing data processing function is a regionwide application.

Priority 6 - Traffic Control

Traffic Control is conceptually one of the primary User Services. It can rely on regional traffic data but can also be focused corridor by corridor where existing surveillance is augmented on a custom-tailored basis for specific traffic control applications. At the arterial level, it is, by definition, a consistent application by functional system utilizing higher level data base processing and traffic control data processing functions, in upgrading from manual to automated, traffic-responsive systems for specific response to incident-related, emergency, or special "seasonal" needs. At the freeway level, the use of ramp metering (corridor-based) requires a management-level application of detection and specific control-related data processing (algorithms). In both cases, the variable message displays are relatively simple. The jurisdiction boundary issue places special emphasis on the interagency coordinationfunction.

Priority 7-9 - Public Transportation Management, Demand and Management Operations, and Commercial Vehicle Electronic Clearance

These longer term priority services appear in the Strategic Deployment Plan in limited applications. For Public Transportation Management, the proposed deployment focuses on a service improvement for PenTran and TRT transit vehicle location and identification services. It would be able to capitalize on the available general regional functions relating to traffic **surveillance and** data processing with communication and location functions operating together with real-time schedule and service analysis. The Strategic Deployment Plan focus on Demand Management includes ramp metering as a key ITS activity in the future in addition to the long-Term expansion of HOV. In the Plan consideration of Commercial Vehicle Operations is limited to maintaining liaison with the on-going Eastern States and Southeastern States Coalitions' review of potential programs for automation of interstate trucking regulatory activities.

SUMMARY

The Strategic Deployment Plan is based on achieving the Priority User Services defined for the region. In developing the User Services, specific generalized functions (as shown in Exhibit 4) will be maintained, upgraded, or implemented based on the developed Plan. This Plan is defined in the next section of the Report.

3. STRATEGIC DEPLOYMENT PLAN

The purpose of this section of the Report is to identify and describe the ITS Strategic Deployment Plan for the Hampton Roads Region. The ITS projects are to initiate implementation in Fiscal Year 1996 and to follow a plan to address the regional transportation needs of Hampton Roads. The Plan includes cost estimates (based on 1995 dollars) and implementation needs and priorities within the Plan.

GOALS OF STRATEGIC DEPLOYMENT PLAN

In defining the Strategic Deployment Plan, several key criteria were defined, as outlined earlier. They are:

- The nature of the initial deployment of the regionwide program needs to be targeted to identify those strategies that have the most immediate and beneficial impacts to Hampton Roads Regional travelers, i.e., aimed at the priority of User Services, i.e. (1) En-Route Driver Information, (2) Incident Management, (3) Pre-Trip Traveler Information, (4) Centralized Information Management, etc.

- The Plan needs to support and enhance the expansion of the common "core" functions, i.e., information processing, surveillance and communications programs to support the Priority User Services and to fill in information "gaps" in terms of gathering real-time data.

- The ITS needs to be deployed to develop, maintain, and enhance a regional plan for seamless coordination of the User Services planned for the region.

- Improved coordination and communication of the transportation agencies in the area needs to be provided to develop support and to maintain early success with the "regional" concept of the COMPARE Program.

The Strategic Deployment Plan has been divided into several stages of development. The stages include a short-Term plan, i.e., activities set for short-Term implementation (l-5 years). This Plan will focus on the development of the critical core functions necessary for other key future improvements and the implementation of early "winners" to display visible and valued improvement projects aimed at building a successful ITS program for the Region. To develop visible and beneficial wide-area projects for Early Deployment, attention must be paid to those technical issues which are institutional in nature. These issues include: coordination and eventual compatibility between different traffic control systems throughout the region; enhancing regional data tbrough expanded and improved roadway instrumentation regionwide;

as well as providing an integrated, reliable database which can incorporate freeway and surface street information and disseminate it in a widespread, yet effective manner.

Once the short-Term deployment projects are in-place, laying the groundwork and infrastructure for the region's ITS program, other additional programs are needed to enhance and exercise the ITS capabilities of the regional system and to add to the capabilities of the system.

A longer term plan (5-20 years) has also been developed. The activities in this plan consist of the logical steps, either geographic or functional extensions of the short-term program, for the provision of additional User Services. The Plan will build on the core functions in the short-term program and the incorporation of new concepts based on technology growth and expansion. In ITS activities, the growth and dynamic nature of the program can result in a vastly changing program of needs, technologies, applications, and solutions to current ITS issues. A Plan developed based on current needs may require several revisions and updates in the next 5-10 year period. As a planning tool and a goal-setting mechanism, a longer term plan is defined for the Hampton Roads Region.

DEFINITION OF STRATEGIC DEPLOYMENT PLAN

It is assumed that the Strategic Deployment projects will be implemented over a period of years. The nature of these projects are that, in the early deployment periods, projects would be aimed at laying the groundwork and infrastructure for the more extensive ITS improvements identified in the Regional Architecture and at developing an ATIS plan for the Region. Later projects would refine the functions and enhance the capabilities of these projects as well as other programs considered instrumental in meeting the region's transportation goals. A definition of the key ITS projects for the Region by functional need and User Service are displayed in Exhibit 6.

Exhibit 6
COMPARE Implementation Plan

Function/Priority and User Service	Short-Term Activities	Long-Term Activities
Surveillance 1 - En-Route Driver Information 2 - Incident Management 3 - Pre-Trip Traveler Information 5 - Emergency Vehicle Management 6 - Traffic Control 7 - Public Transportation Management 8 - Demand and Management Operations	Coordinate Bridge and Tunnel Data from Bridge/Tunnel Authorities with VDOT/Regional TMS (Software Development).	
	Extend VDOT Surveillance Systems along Interstate in Region.	
	Extend/Upgrade Arterial Surveillance System along Regional/Arterial Highway System.	Extend CCTV Coverage along Regional/Arterial Highway System (est. 10 sites/year). Extend Weather/ Environmental Sensor Coverage along Regional Arterial (est. 4 sites/year) Highway System.
	Encourage Adoption of "#77" Cellular Call-In Program Regionwide.	Implement Transit AVI/AVL System for PenTran and TRT and AVL System for Emergency Vehicles Regionwide.
Communication 4 - Centralized Information Management Other 8 Priority User services Indirectly	Provide Remote User Station Capability for Region's Transportation Agencies and Utilize Existing Fax/ Telephone/Modem/E-Mail Systems (Interim).	Provide Video Conferencing for Region's Transportation Agencies.
	Develop Communications Network Regionwide.	
	Develop Information Exchange Network.	Enhance Information Exchange Network and Expand to Other Districts and Regions.
Information Processing 1- En-Route Driver Information 2 - Incident Management 3 - Pi-e-Trip Traveler Information 4 - Centralized Information Management 5 - Emergency Vehicle Management 6 - Traffic Control 7 - Public Transportation Management 8 - Demand and Management Operations	Develop Manual Input to Clearinghouse for Regional Data (interim).	
	Expand VDOT TMS to Meet Regional Architecture Needs.	
	Upgrade and Automate VDOT/Regional TMS System.	

Exhibit 6
COMPARE Implementation Plan

Function/Priority and User Service	Short-Term Activities	Long-Term Activities
Traveler Interface Systems (TIS) 1 - En-Route Driver Information 2 - Incident Management 3 - Pre-Trip Traveler Information 4 - Centralized Information Management 5 - Emergency Vehicle Management 6 - Traffic Control 7 - Public Transportation Management 8 - Demand and Management Operations	Implement HAR Regionwide and Upgrade to AHAR.	
	Implement Interactive Kiosks at key Public Generators and Key Arterials To and From the North Carolina Border Area.	Implement Interactive Kiosks at Other Major Generators .
	Implement VMS at Major Freeway-to-Freeway Points and Key Arterials To and From the North Carolina Border Area.	Implement VMS at Major Freeway Diversion Points and at Key Arterial Decision Points.
	Upgrade Phone-Based "1-800" Traveler Information System Regionwide.	
	Promote Commercial TV Usage for Traveler Information Purposes.	
Traffic Control and Management 2 - Incident Management 4 - Centralized Information Management 5 - Emergency Vehicle Management 6 - Traffic Control 7 - Public Transportation Management 8 - Demand and Management Operations	Expand Existing Signal Systems (includes adding signal system for Williamsburg) ,Regionwide.	Extend Signal Systems as New Signals are Installed (est. 30 intersections/year) Regionwide.
	Expand Number of Signal Timing Plans and Traffic Responsive Feature for Signal Systems Regionwide.	
	Expand Emergency Vehicle Preemption Systems Regionwide.	Implement Regionwide Ramp Metering (Staged).
	Provide Signal Coordination/Cooperation Across Jurisdictional Boundaries Regionwide.	Provide Greater Signal Coordination Cooperation Across Jurisdictional/ Boundaries Regionwide.
	Implement Automated Incident Detection Algorithms for Interstates.	Implement Automated Incident Detection Algorithm for Regional Arterial Network.
	Computerized Incident Response Lists for Regionwide Application.	
	Develop CAD for Emergency Response of Highway Incidents Regionwide.	
	Automate Regional Traffic Diversion Plans.	Implement Automated, Real-Time Traffic Diversion Algorithm.

It is not possible to foresee the most cost-effective technology providing any given functions more than 2-3 years into the future. Specific technologies are used to determine order of magnitude costs, but there is no presumption that the 1995 "best practices" will prevail over the life of the long-term proposals and, in some cases, not over the span of the short-Term proposal. Therefore the proposed Plan is "strategic" in that it is presented in term of functions rather than specific technologies. The following sections describe the recommended projects and Implementation Plan by these specific functions.

SURVEILLANCE

SCOPE AND RECOMMENDATIONS

Nearly all of the ITS Priority User Services for the Hampton Roads Region depend on collecting, processing, and managing information on the transportation network. The importance of accurate and reliable surveillance information cannot be overstated. It is truly the "heart" of ITS. Surveillance data – including speed, volume, density, travel time, queue length and vehicle identification and position – are used in real-time for making transportation management decisions (Incident Management, Traffic Control), selecting traveler information displays (En-Route Driver Information, Pre-Trip Traveler Information) and implementing appropriate control strategies (Traffic Control, Demand and Management Operations). The information may also be stored for planning and historical analyses. The primary applicable functions include: traffic surveillance, vehicle surveillance, and in-vehicle sensors.

Surveillance Plan Recommendations

The surveillance activities covered under this plan include: the highway network, transit vehicles, and weather/environmental conditions. The proposed regional Surveillance Plan for the Hampton Roads highway network is shown in Map 4 (displayed in Appendix C).

In support of the Surveillance Plan, the following recommendations are provided.

- Bridge and Tu[redacted] Information - Develop interface and provide physical connection of bridge and tunnel data to VDOT TMS. The VDOT TMS does not currently have provisions for access to this data, mainly because the current software system is not compatible with the TMS. To provide a continuous surveillance network along the Interstate, the bridge and tunnel data should be incorporated into the regional system.

- Freeway VDOT Surveillance Systems - VDOT currently collects traffic flow data in areas outside the bridge and tunnel network with permanent count stations. In addition to these stations, plans have commenced to install CCTV and increase detector stations (volume, speed, occupancy) to every half mile in the section of I-64 (from the Hampton Road Bridge Tunnel area south to Indian River Road), I-264 (from I-64 west through the City of Norfolk), Route 44 (from I-64 east to near Lynnhaven Parkway), and I-564 (from I-64 west to the Naval Base). This system should be extended in the short-Term to complete coverage along I-64, I-264, I-464, I-664, and Route 44. In addition, weather/ environmental sensors should be installed at major/key bridges in the area for early detection/warning advisory systems of adverse weather conditions.

- Arterial Surveillance Program - The existing local systems should be expanded to include the regional arterial network, including principal arterials, as shown in Map 2 (Appendix C). On a short-Term basis, the surveillance data should use the existing local communication and processing capabilities of the local signal systems with eventual operation separate from existing local signal systems to better permit collection of real-time surveillance data. CCTV, at selected locations on major corridors as shown in Map 4, should also be planned.

- Supplemental Freeway Surveillance - The full deployment of #77, including a comprehensive public awareness program and coordination and integration of the operation within the VDOT TMS Center, would prove useful in providing surveillance of highway incidents as well as traveler information to the Hampton Roads area travelers.

- Transit Systems Surveillance - Given plans for public transit systems as a vital means of transportation in the Hampton Roads area, a longer term plan should include the deployment of AVI/AVL systems for the region's transit systems.

Plan Considerations and Components

Existing Conditions/Plans

Data collection is critical to the development of a solid ATIS network. The collected data must be timely, relevant, and reliable. The data must be integrated into the traffic management system (TMS) and must be of high value to the system. Existing surveillance/data collection sources in the Region are defined below.

- Bridge and Tunnel Information - Traffic flow data is currently collected on many of the bridges and tunnels through the use of inductive loops and CCTV. This data is used for traffic management purposes in the tunnel and bridge areas. Access to the data is currently limited to the individual bridge/tunnel communication centers located at the bridges.

- Freeway VDOT Surveillance Systems - VDOT currently collects traffic flow data along the Interstate in areas outside the bridge and tunnel network with permanent count stations. In addition to these stations, plans have commenced to install CCTV and increase detector stations (volume, speed, occupancy) to every half mile in the section of I-64 (from the Hampton Road Bridge Tunnel area south to Indian River Road), I-264 (from I-64 west through the City of Norfolk), Route 44 (from I-64 east to near Lynnhaven Parkway), and I-564 (from I-64 west to the Naval Base). In addition, weather/environmental sensors exist at several key bridges in the area for early detection/warning advisory systems of adverse weather conditions.

- Arterial Surveillance Program - Several local agencies have system detectors (volume, speed, occupancy) situated in the field for use in traffic management systems. Local detection also exists at most signalized intersections for individual actuated intersection control. Emergency vehicle pre-emption equipment also exists at a few intersection throughout the region, as defined in the jurisdictional ITS inventory (Appendix B) of the Task 1 Initiative Report.

Standards and Coverage

A continuous, comprehensive coverage of the regional highway systems (including Interstates) is proposed. In general, the freeway (high-speed roadway) or Interstate segments are planned for 1/2 mile-detector spacing. CCTV coverage is also planned throughout at a comparable rate of devices. Piezo sensors are proposed at l-mile spacing along the Interstate. The intensive monitoring of traffic flow provided by 1/2-mile spacing will also be utilized for automated incident detection along with congestion monitoring for traveler information. These spacings are comparable to the existing plans by VDOT and favorable for future surveillance needs.

The non-freeway regional highways are proposed for one to three mile detector spacing. The closer spacing is recommended for the more congested highways and the far extreme recommended for the less congested highways. For all non-freeway highways, the detectors are used to monitor congestion, estimate travel times, and develop reliable traveler information. CCTV is also proposed along several other major arterial corridors for surveillance purposes. The coverage areas are also displayed in Map 4. The selection of these areas is based on existing congested corridors, existing high accident locations, and future projected congested corridors/areas. It should be emphasized that the various spacing criteria discussed above represent guidelines. The actual spacing between adjacent detector stations will be dependent on several site-specific factors which may include: locations of existing "system” detectors, accessibility of power and communications connections, presence of signalized intersections and stopped vehicle queues, location of driveways or other intersecting roadways, and physical features of the pavement or roadway system.

Function/Technology Applications

The near-term recommendations for detector technology are based on use of proven technology and utilize existing facilities whenever feasible. Depending on the state of the detector technologies and their respective costs at the time of implementation, it is very possible that segments of the Strategic Plan will incorporate other types of detectors. Possibilities include:

- Radar Detectors
- Video-Image Processing (VIPs/Photographic)
- Vehicle-Probes
- Cellular Phones
- Passive Acoustic Units
- Others (based on new technologies)

Freeway

It is recommended that the VDOT Plans for loop detector installation be maintained along the Interstate system. VDOT is in the process of installing a loop detector network along the Interstate. Each station will consist of a loop-pair in each lane, thereby providing the ability to measure volume, speed, occupancy, and length on a lane-specific basis. On-going tests of new passive acoustic detectors (by AT&T) may supercede this recommendation, however. Vehicle classification information will also be provided every mile or between interchanges using piezo cable at the detector stations.

To supplement the freeway surveillance program (as used in other parts of the State for incident detection purposes), adoption and implementation of the "#77" emergency response system should result. The system will allow a traveler with a cellular phone to call the State Police in the area and inform them of incidents and congestion conditions. This information will be forwarded to the TMS for traffic management purposes.

Non-Freeway

Along the non-freeway segments of the regional highway network, new roadway detectors will be required. Where an appropriate support structure (e.g., overpass, sign) exists, and the detector spacing requirements are satisfied, the use of overhead-mounted detectors, e.g., forward-looking microwave, is recommended for those areas. A microwave detector would be installed over each lane, and the connecting cables from the detectors terminated in a ground-mounted cabinet complete with power and communications. At those locations where an existing overhead support does not exist (most planned detector locations), new loop stations--consisting of loop-pairs in each lane and a ground-mounted cabinet are recommended for installation.

The proposed detector configuration will provide, as a minimum, lane-specific speed and volume data on a real-time basis. This level of information is required for developing reliable traveler information (En-Route Driver Information, Pre-Trip Travel Information), detecting incidents (Incident Management) and providing a historical record of traffic conditions. The loop-based stations will also provide vehicle classification (i.e., vehicle length) data.

Environmental

Weather and environmental conditions have a significant impact on traffic flow through their effects on visibility, the surface condition of the roadway, and atmospheric conditions. In many cases, these conditions may reflect adverse roadway conditions that will require further maintenance by highway agencies and warning and notice of safe driving speeds to motorists. In a roadway ITS application, road surface and environmental information can be used to alert highway agencies of further maintenance needs, to modify the traffic management and control strategies (e.g., incident detection calibration factors, ramp metering rates), and for tailoring the traveler information on variable message signs (e.g., "ICY CONDITIONS AHEAD") to reflect roadway and environmental conditions and to provide advance or greater warning of adverse conditions. Roadway surface sensors depict air temperature, pavement temperature, pavement moisture, and other key roadway surface characteristics. Atmospheric sensors include air temperature and humidity readings, optical sensors that detect the onset and termination of any type of precipitation, wind speed and direction measurements, and visibility measurements reduced by fog, rain, snow, smoke, blowing sand, etc.

As part of the Strategic Plan, it is recommended that additional roadway surface and atmospheric sensors be installed at the following locations:

- Route 17 across the York River bridge
- Chesapeake Bay Bridge area
- Route 17 bridge south of Highway 32
- Route 17 bridge across the Nansemond River

- Route 17 bridge west of I-664
- Route 194 bridge near Portsmouth
- I-64 bridge south of I-264/Route 44
- I-64 bridge west of Route 17
- I-64 bridge north of I-264/Route 13 to Suffolk
- Route 104 bridge north of Route 165
- Route 168 Bypass bridge
- Route 168 bridge north of North Carolina state line
- I-464 bridge south of I-264
- I-264 bridge east of I-464
- I-264 bridge west of Route 17 (Military Avenue)

As part of the longer-term plan, upgrade of equipment at existing installations is proposed.

Transit

Future plans for transit systems in the Region include public transit as a vital means of transportation in the Hampton Roads area. Effective transit operations will require a level of improved operations that inclusion in the ITS system can support. This system will be dependent on the use of locational and other transit system characteristics data. Real-time data on transit vehicle locations will be used to enhance operations control and passenger information. The transit information will also be integrated with the regional highway network data to provide a multi-modal traveler information database throughout the region. Therefore, real-time surveillance of transit modes will be an important function of the Hampton Roads ITS network in the future.

It is recommended that the Strategic Deployment Plan include the deployment of AWAVL Systems in the Region's transit systems. Extension and expansion of TRT's existing "sign post" system may be feasible. The functions of the AW AVL systems will be dependent on the needs of the systems in the future deployment year as the multi-modal transportation demands in the Region reflect a more public transit-oriented use.

Emergency Vehicles

The use of AVL is recommended for use on emergency vehicles (such as police, fire, and ambulance vehicles) in incident management situations. Recent experiences with AVL systems should be investigated to ensure cost-effectiveness of specific systems currently undergoing operational tests.

COMMUNICATIONS

SCOPE AND RECOMMENDATIONS

The Hampton Roads ITS network will be comprised of many different elements--field components such as variable message signs, detector stations, ramp meters, and CCTV cameras; central equipment such as computers, workstations and monitors; and the human element (i.e., system operators and maintenance personnel). For the system to function properly, it will be necessary for each of these components to exchange information with other system elements. Data, voice and video communications are needed at various locations within the ITS network. It is the communications network which will provide the connecting link for this information. The primary applicable functions include: l-way mobile communications, 2-way mobile communications, stationary communications, inter-agency coordination, as well as the surveillance functions.

The communications network is an integral part of the overall ITS design in that it affects (and is affected by) system architecture, configuration, and the operational strategies. Moreover, when thought of as a single expense, the communications network is the costliest item of an ITS-based system. It also typically contains some of the most complex and advanced technology deployed in the network.

Communications Plan Recommendations

In support of the Communications Plan, the following recommendations are provided.

- **Regiona Field Communications Network** - In the short-term, develop a communication network (regional backbone) along the Interstate system to the VDOT TMS, which will house the regional clearinghouse and serve as the TMS for Interstate and inter-regional travel. Communication to and from the local Transportation Operations Centers (TOC's) will be linked to the VDOT TMS via the regional backbone and a communication link (from TOC to hub along the backbone) consisting of either agency-owned high-capacity cable or leased services. A final level of communications is the communication from the field elements to the local agencies' TOC's. This network is planned to utilize existing technologies used by the agencies and based on their own favorable experiences (e.g., radio-city of Portsmouth; twisted-pair cable-Newport News, Virginia Beach, coaxial cable-Norfolk, etc.)

- Remote User Access for Local Agencies to VDOT TMS - Promote and provide access to VDOT TMS electronic bulletin board and databases for inter-agency communications in the short-Term.

- Information Exchange Network - In the longer term, develop this tool to achieve the communication objectives of the Region and to facilitate communication and information sharing among agencies and private entities. This information network will take on many formats including: text, electronic forms, data files, map-based graphic displays, and video. Moreover, the information shared on the network will be designed to support coordinated incident and transportation management efforts, and provide traveler information on a regional basis. Uses of the network, for example, will include alerting other agencies and the traveling public of major incidents and their impacts on traffic; communicating unusual conditions on another agency's facilities; displaying construction/maintenance activities on map displays of the highway system; and creating an integrated clearinghouse function containing of real-time, multi-modal traveler information.

Plan Considerations and Components

Existing Conditions/Plans

Two levels of communications are defined in this section The first is the communications between ITS-related elements (e.g. VMS, detectors, intersection control/ controllers, etc.) in the field and traffic operations centers. The second level is the communication between agencies, e.g. in responding to a highway incident or in discussing traffic diversion needs associated with an event or an incident.

A range of communication methods are utilized throughout the Region to communicate with the ITS field devices. These methods range from twisted pair cable and coaxial cable (as used to connect individual intersection control and for several signal system operations) to leased telephone lines (as used for intersection and signal system control and VMS operation) to fiber optics cable (as used for video surveillance in the several bridge and tunnel areas in the region). The use of these methods are based on the data requirements of the application and the preference of the individual agencies requiring the communication.

A regional communications network does not currently exist. Plans are underway, however, to investigate, develop and implement a communication backbone along the interstate highway system throughout the Region. One option includes the development of a fiber-optics cable plant. Fiber-optic cable provides the necessary capacity and could be developed through public or private ownership, lease or other resource-sharing arrangements. Fiber-optic hubs would be planned at key junctions along the Interstate network. Access and use of this fiber optics plant would occur at these hubs. Inputs from off-Interstate data sources, local traffic operations centers, as well as other field elements of the VDOT operation would take place at these hubs. The conceptual plan for this option is displayed in Map 5 (Appendix C).

Communication of local agency-supplied field data or information from the local agencies' field elements to a regional transportation center does not currently exist. Away from the Interstate, the communications methods vary by agency (as displayed in the inventory of ITS elements provided in Appendix B of the Initiative 1 - User Services Report). These methods, in general, provide communications between the field elements (where it does exist) and the local traffic operations centers.

Inter-agency communications in the Hampton Roads Region exist by several means. Primary communications media includes telephone access with fax and modem service between agencies on an "as-needed" basis. Dedicated communications links between the agencies do not exist.

Standards and Coverage

The proposed regional communications network is displayed in Map 6 (Appendix C). The type of information (voice, data, video) to be communicated within each level of the network (field-to-control, control-to-control, control-to-traveler) will indicate the bandwidth requirements and the technology implied. The system will consist of a regional communication network along the Interstate system to the VDOT TMS, which will house the regional clearinghouse and serve as the regional TMS. Communications to and from the local Transportation Operations Centers (TOC's) will eventually be linked to the VDOT TMS via the regional backbone and a communication link (from TOC to hub along the regional backbone) consisting of leased or agency-owned fiber-optic lines. Initial deployment for voice and most data applications can be through lower speed dial-up connections although full motion, real-time video will require fiber-optics cable as its medium. At this time several alternative approaches (e.g., agency-owned cable, leasing, resource sharing) are being investigated by VDOT for use along the Interstate and as the regional backbone.

A final level of communications (not shown in Map 6) is the communications from the field elements to the local agencies' TOC's. This network is planned to utilize existing technologies used by the agencies and based on their own favorable experiences (e.g., radio-City of Portsmouth; twisted-pair cable-Newport News, Virginia Beach, coaxial cable-Norfolk, etc.). In the interim, these links will be based on the information needs required for each agency. For example, where voice or data lines are required, leased telephone lines or agency-owned cable will be used. As agencies upgrade to full video requirements, fiber-optic lines (leased or owned) will be required.

The distance requirements of the Hampton Roads Region, coupled with cost and reliability considerations, dictate a distributed configuration with one or two tiers of hubs. The distributed configuration will require the placement of communication hubs at locations in the field to gather and distribute data and video. In many cases, these distribution points or hubs will exist at the local agencies' traffic operation centers (TOC's) In other cases, particularly for VDOT needs along the Interstate system where significant amounts of data, voice, and video will be distributed and where substantial bits of data will be communicated between the TOC's and the regional clearinghouse at the VDOT TMS Center, additional hubs will be needed to gather, process, and distribute the data. These hubs divide the network topology into two basic divisions:

- Trunk circuits for hub-to-hub and hub-to-control center communications. The data transmissions are high-speed conforming to T-carrier or SONET standards.
- Distribution circuits are used for the exchange and distribution of digital data messages between the hubs and the field elements.

The various field elements comprising the Hampton Roads Regional ITS network will require different bandwidths and network availability. Therefore, the detailed design of the field element communications, should be performed on a case-by-case basis in order to provide the most cost-effective solutions.

Future/Technology Applications

Detection and Ramp Meter (Future) Controllers

Both the detector stations and ramp meters (future) along the interstate are proposed to use the same processing/controller hardware--a Type 170 controller. These will be the most numerous field devices in the system being located at on-ramps and at nominal 1/2-mile intervals along several segments of the freeway--approximately 3 or 4 per mile in the "high density" segments. Communications between the hubs and the Type 170 processors will be on a regular polled basis requiring full time availability.

For detection stations along the arterials, the detector processing capabilities associated with the agencies' current signal systems (where real-time capabilities exist) will be utilized. Where a signal system does not exist or the signal system surveillance capabilities are limited, detector stations should be proposed to use Type 170 controller (or its future replacement, the MODEL 2070) capabilities and the detector data gathered at the TOC. Communication between the TOC's (hubs) and the detector processors should be on a regular polled basis requiring full-time availability.

Other Detect-

In addition to the vehicle detectors for measuring volume, speed, and classification (where feasible), additional detectors will be installed along the selected segments of the freeway and arterial network for pavement and environmental conditions (e.g., dry, wet, ice, fog, general visibility, etc.). These additional detectors will communicate over separate low-speed channels to a hub on a regular polled basis. Accordingly, these channels will require full-time availability.

Variable Message Signs

Variable message signs will use a field controller furnished by the sign vendor and compatible with the system-wide VMS protocol and format. VMS communications will use the same type of data channels as detectors and ramp meters, but on channels separate from the vehicle detectors and ramp meters. There is a requirement for 100 percent availability for "instantaneous" message display when required and for verification purposes, though this will occur probably less than 10 percent of the time.

Video Equipment

The purpose of video surveillance is incident verification and congestion management (in designated areas), requiring only short duration visual information. However, during these processes, the video should preferably have resolution and sharpness near broadcast quality video. The video network for the interstate cameras will have to be available 100 percent of the time for incident verification and other surveillance functions, though the time that most of the cameras will be used for that purpose will be relatively small. The exception to this general rule might be construction areas where the detectors are disabled, and when it becomes necessary for the system operators to constantly monitor the freeway (via CCTV) for congestion management and incident detection The video network for arterial (selected locations) cameras will have to be available 100 percent of the time during periods of high levels of traffic activity (e.g., daytime hours-weekday; special event periods--weekends, evenings, and nighttime; etc.) for incident verification, surveillance, and traffic management functions.

Current proposals to VDOT along the Interstate system call for the video transmissions to be digital based on a fiber-optics communication network. An alternative to this system (SONET network) that could interface with the TMS communications system while providing alternatives for equipment and/or services procurement has been addressed as an alternative.

Reversible Roadway Gates

This system exists at the entrance and exit ramps to and from the high-occupancy (HOV) facilities in the Hampton Roads Region. This system exists as a specific function of VDOT's TMS system and is expected to be operated under VDOT control.

Inter-Agency Communications

One of the more high-profile programs to be developed as part of the regional ITS system will be the inter-agency communications, a primary function of the Priority User Service, Centralized Information Management, and a key function of each of the Priority User Services. Under the current VDOT TMS plans, a portion of this objective will be met with the availability of remote access to an electronic bulletin board. At this time, the information to be communicated to the bulletin board is planned to be limited to data/information supplied by specific users within the system. This type information may include: incident information, special equipment requests, and key meeting notices relative to the COMPARE Program. This capability should be enhanced and expanded to include the information exchange for all key transportation-related agencies that comprise the Hampton Roads COMPARE Program.

Information Exchange Network

An effective means to achieve the communication objectives of the Region will be through an information exchange network (IEN). An IEN will facilitate communication and information sharing among agencies and private entities. This information network may take on many formats including: text, electronic forms, data files, map-based graphic displays, and video. Moreover, the information shared on the network can be designed to support coordinated incident and transportation management efforts, and provide traveler information on a regional basis. Uses of the network, for example, may include alerting other agencies and the traveling public of major incidents and their impacts on traffic; communicating unusual conditions on another agency's facilities; displaying construction/maintenance activities on map displays of the highway system; and creating an integrated clearinghouse of real-time, multi-modal traveler information.

The information and functions which can be supported by an IEN may include the following:

- Administration
- Incident Tracking and Management
- VMS and HAR/TAR
- Construction Events
- Static Help
- Decision Support
- Traffic Condition and Status
- Historical Data
- Traveler Information
- Video

Conceptually, an IEN consists of computer workstations and servers connected by a wide-area network (WAN). The system architecture will be distributed in nature, with workstations (and automated system interfaces) located at the agency members sites and traffic centers (TOC). A few servers may be used to perform the following specialized functions:

- A Regional Server (located at TMS) can process and aggregate the real-time transportation link information--received from the various member agencies via automated interfaces to their ITS-based systems -- into a single representation of the region. This server can also store information (e.g., link data, incident summaries, construction events, and schedules) for historical purposes, and handle inter-region communications.

- Advanced Traveler Information System (ATIS) servers can "filter" the information contained in the IEN database and provide a gateway for subsequent dissemination of this information to travelers via broadcast media, private kiosks, in-vehicle devices, etc.

Other Inter-Agency Communications Needs

Once the planned implementation of the regional backbone communications system is completed along the Interstate system and the communications plan (agency TOC to hubs) is completed (for the short-Term period), data, voice, and video communications between agencies will be able to be effectively achieved. However, in the interim, other means such as: fax, telephone, modem, or electronic mail (as may be currently used) will need to be employed. These methods currently exist, in some form, within most of the agencies part of the Hampton Roads Region. Contact names, phone/fax numbers, and access addresses should be developed and maintained on a regional basis for each agency/entity part of the Hampton Roads Region.

INFORMATION PROCESSING

SCOPE AND RECOMMENDATIONS

The collection, assembly, summary, and analysis of the data collected in the field and the subsequent use of the findings in a user-friendly manner represents a critical function in the ITS activities. Identified as processing of the data and information, this function is critical at two points. First, the data obtained in the field must be assembled and understood at the local level, i.e. information from a specific field device must be handled and interpreted as input from the specific location. Second, the information from multiple points or locations must be assembled and summarized in an effective way to define characteristics. For example, surveillance data from an area must be assembled to define the area's characteristics relative to the area's conditions. In this way, travel speeds along a highway corridor are defined. The processing levels and needs in both instances vary considerably. However, both levels represent key steps in the development and use of the information for ITS purposes, e.g. traveler information, traffic control, etc. The applicable functions include: database processing, traffic control data processing, traffic prediction data processing, routing data processing, as well as the surveillance and communications functions.

Information Processing Recommendations

In support of the Information Processing Plan, the following recommendations are provided.

- Local Processing - Provide modem and software interface capabilities for upload/download of local data for regional use. Existing local information processing capabilities will initially be used. For most local agencies, this will include the processing of data through the existing local operations centers' system. Upgrade of this system to an independent operating system is proposed in the longer term. For VDOT and its Interstate system, continuation of the current surveillance data processing system (Type 170's) is planned, as proposed in the current VDOT TMS plans.

- Expansion of VDOT TMS - For the short-Term, enhance and expand the VDOT TMS capabilities for regional needs. Activities will include:

Expansion of graphic features to include the major regional routes.
Expansion and promotion of remote access to databases by all local agencies and approved groups.
- Expansion of databases to reflect regional highway system and needs/ uses of local agencies.
Capability to upload and download regional traffic data.
Development of Regional Operations Committee.
Implementation of workstation (containing fax and modem capabilities) and telephone communications in TMS Center for regional use.
- Investigate the Internet for dissemination of traveler information.

- Regional Processing - To further meet the regional needs of the planned system, the following recommendations are provided for the longer term.

  - Expand GIS system regionwide
  - Develop expert systems capabilities for feasible functions, such as: incident response, traffic diversion needs, and incident prediction

Plan Considerations and Components

Existing Conditions/Plans

Local Processing

At the local level, the roadway detector/ surveillance devices are processed by one of several means including:

- Preprocess the data in the field, accumulating speed, volume, and occupancy measurements over a specific time period (e.g., 20-seconds to l-minute), and then transmit the information to a central facility. The field processor also performs initial error checking of the collected data.

- Preprocess the data as noted above, but further analyze and store the information, transmitting to the central facility only on an "event-driven" basis. For example, the field processor may execute automated incident detection algorithms and transmit an alarm whenever a possible incident has been detected; or the processor may calculate and store average speed data, but transmit the information only when this speed value falls into a different, predefined speed-bin (e.g., 0-20,20-30,30-45,45 mph +).

The exception basis scenario (i.e., event-driven) places the minimum burden on the communications network allowing "dial-up" communications, although field hardware that possesses the required processing capabilities and the associated firmware are just now being offered. Most traffic systems use the first scenario -- preprocessing the data and transmitting the information regularly. This approach is being used by VDOT for its processing of data along I-64 and is planned along the interstate system (using Model Type 170 processor units). The data, then, is planned for download to VDOT's TMS center. Several local traffic systems (e.g., City of Virginia Beach) also operate on this concept.However, detector processing for most local traffic control systems (e.g., the closed loop system of the City of Suffolk, City of Newport News, City of Norfolk, etc.) is achieved by the second approach. On a request basis, the data is processed in the field at the local control and downloaded to the master controller for subsequent download to the agencies' traffic signal computer. Retrieval of the data is relatively "slow" and cumbersome.

Once the local data is processed, the data is organized and formatted for specific local applications. In the case of the closed loop and other signal systems, information is normally formatted in summary tables by volume, speed, and (optional) occupancy by detector location. Some upgrades to this system do exist to allow display of the traffic information on a larger scale basis. The data/information is typically being used for historical traffic count and analysis programs.

For VDOT - maintained detector data collected along the Interstate, plans are to process the data in the field (using type 170 processors) and download the data to the VDOT TMS Center for areawide processing. The VDOT TMS Center is currently preparing for full-scale operation of VDOT activities. The Center, as defmed in the regional architecture statement, will also serve as the primary functional processor of the surveillance information for regional applications.

Regional Processing

The architecture for the planned VDOT TMS central hardware (as documented in VDOTs Conceptual Design Report - 1993 and submitted to NEC by VDOT - 1995) is shown in Exhibit 7. The TMS will be composed of numerous interconnected subsystems. Each subsystem will be run by a separate PC. A key feature of the design is that each subsystem will function regardless of whether the others are operating. The modular design allows one aspect of the system, such as ramp metering, to be upgraded with no change or disruption to the remainder of the system.

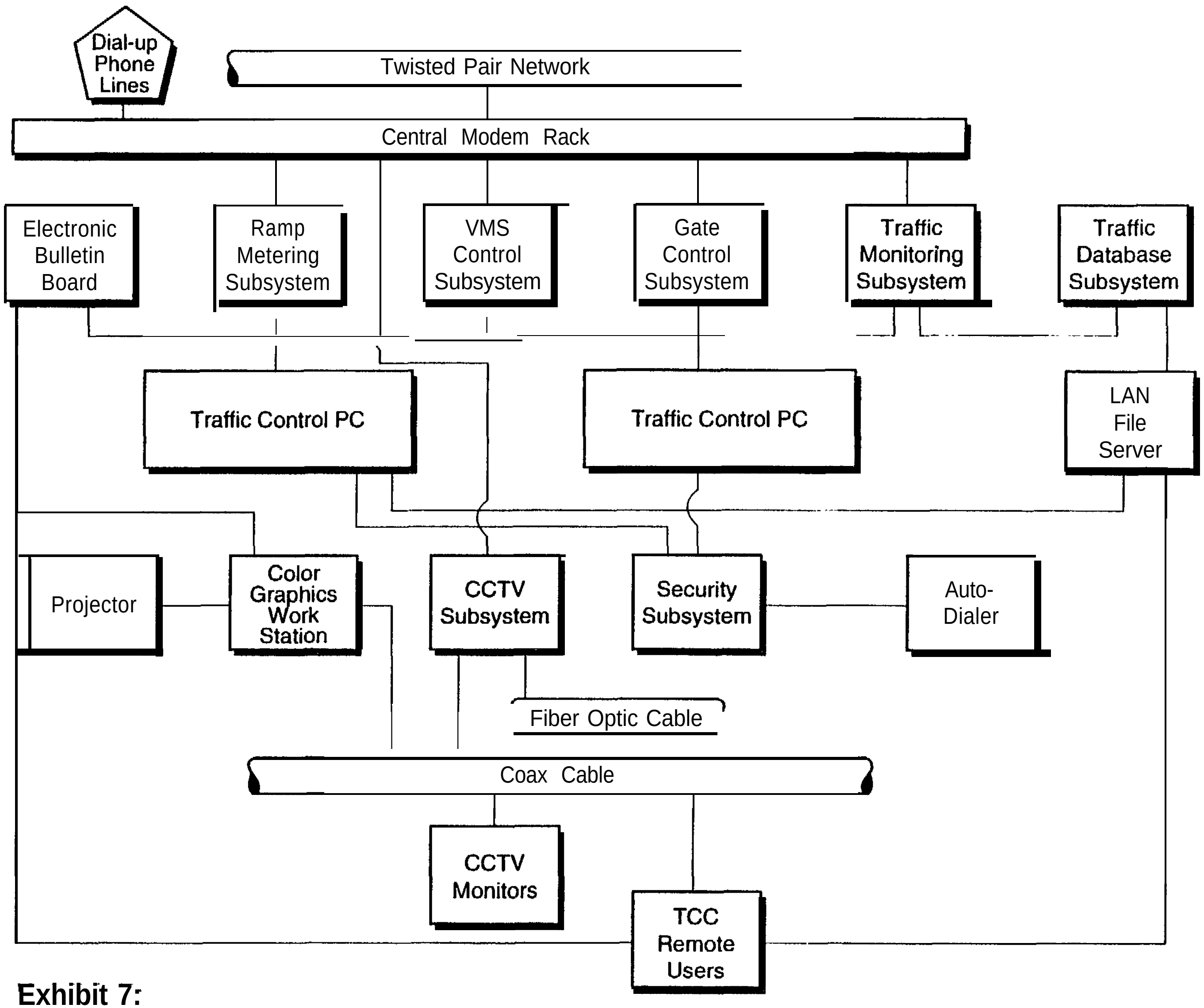


Exhibit 7:
VDOT TMS Functional Block Diagram

The TMS, upon completion under current plans, will have seven subsystems, as follows and as depicted in Exhibit 7.

- Closed circuit television
- Traffic monitoring
- Traffic database
- Ramp metering
- Reversible roadway gates
- Variable message signs
- Security alarms

These processing systems, currently under development by VDOT, are described in Appendix B.

Standards and Coverage

User Interface at the Traffic Control Center

Users will interact with the TMS via powerful desktop PCS or "workstations." These workstations will consist of 486 microprocessors and a 14-inch color monitor; and will be equipped with a graphics accelerator card and a video card, as well as the software necessary to communicate over a Local Area Network (LAN) system and to an Electronic Bulletin Board. The TMS user workstations will be connected by a local area network and other wiring to computers and video equipment that provide each user with the following capabilities:

- Graphic displays showing incidents, traffic conditions, and the status of equipment.

- A video image from a selected camera, or a sequence of images from a series of cameras.

- A text report, either printed or on the screen.

- Ability to control cameras, ramp meters, signs, and gates, subject to certain restrictions. Passwords will be used to allow certain users to have control privileges that others do not have.

- Ability to read and post data about incidents on an electronic bulletin board system shared by traffic reporters, emergency response agencies, and local jurisdictions.

- Ability to send and receive electronic mail messages to other workstations on the local area network.

User Interface At Remote Locations

Users at locations outside of the TMS will have the ability to access the VDOT TMS facilities utilizing workstations equipped with a modem. These workstations may be identical to the workstations located in the TMS, except that the capability to receive video signals would be reserved until in the future when the demand exists. These users will be able to display the traffic information graphically, with automatic updates to show current conditions.

Private users, at locations outside the TMS may also utilize their own PC equipped with a modem. These users will have the capability to dial in to a computer at the TMS to get current information about incidents and traffic conditions. This information will be available to the user in tabular form only, and will cover not only incidents detected by the TMS, but also those reported by traffic reporters and other jurisdictions. Authorized users will also be able to post information about incidents on the computer system, like the VDOT TMS staff.

Function/Technology Application

Local Processing

At the local level, the VDOT approach to detector processing, i.e., preprocessing the data and transmitting the information regularly using Model Type 170 processing capability, meets the flexibility needs of the regional system. The data, then, is planned for download to VDOT's TMS center.

Detector processing for most local traffic control systems (e.g., City of Suffolk, City of Newport News, City of Norfolk, etc.) is currently achieved on a request basis. The detection area is requested, the data processed in the field and the data downloaded to the master controller for subsequent download to the agencies' traffic signal computer. Retrieval of the data is "slow" and cumbersome. In the short-Term, the existing closed loop systems will require expansion of detector processing capabilities to bettor meet the regional surveillance needs (e.g., real-time information) required of each agency. A separate vehicle surveillance/processing system for the regional highway system is proposed, as displayed in Map 4. In the interim, once the detector data is transmitted to the agencies' traffic center, a software interface and modem access capabilities should be developed to format the detector data into a common format for the regional database and to download the data to the regional system. This software can also be used in the long-Term for processing the local data for regional needs. For other signal systems (such as Virginia Beach's Multisonics VMS system), similar interfaces and modem capabilities will be required.

Perhaps the most important consideration with regards to detector processing is flexibility. Given the rapidly changing detector market and the range of detector processing equipment currently being used in the Hampton Roads Region (e.g., closed loop capabilities, Type 170 controllers, etc.), an ITS-based system must be capable of obtaining traffic flow measurements using several different detector technologies, while also providing this real-time information to the control center in a single standard format. In this manner, the system should not be locked into a specific technology or vendor. New detector technologies can be integrated into the system as they become available and proven, while the processing at central remains consistent. Preprocessing the data in the field provides an open architecture for detector data processing, while also minimizing the central data processing requirements.

In addition to roadway detector processing, other ITS applications (e.g., incident detection, variable message signs, pavement condition sensing, automatic vehicle identification, electronic toll collection, pollution monitoring, in-vehicle signing and guidance) will require a field processor that is powerful enough to compute mathematically intensive algorithms, is easily programmable, and will support multiple communication media and ports. As previously noted, the Type 170 controller has been widely used for detector processing as well as signal and ramp meter control.

Regional Processing

The architecture for the Hampton Roads Region is proposed as a distributed, organization-based structure. Each transportation agency (e.g., VDOT, HRPDC, State Police, local jurisdictions, etc.) monitors and operates its respective facilities via its agency-specific Transportation Operations Center (TOC). The regional Transportation Management System Center (TMS) provides fusion of data from the TOCs, coordinated incident management, and strategic operations in accordance with pre-approved plans during situations with regional impacts.

The overall architecture and system functions indigenous to the local control centers is diagramed in Exhibit 8. Summarizing:

- The regional ITS network centers around the collection, evaluation, and dissemination of traveler information--both Pre-Trip and En-Route. The local TOCs collect data from their respective surveillance devices and other resources--both automated and manual. This information is used to monitor conditions on their facilities and to develop and implement appropriate strategies.

- These data are also passed automatically to the TMS, where it is merged with data from other TOCs to provide a region-wide Clearinghouse function. This traveler information database is proposed to be based on a geographic information system (GIS) in the future, thereby providing a common reference for the large volume of spatial data and for correlating position-related information obtained from various sources (e.g., #77, detectors, etc.).

- The traveler information database resident at the TMS--which is proposed to include graphic, text, and video displays--can be called up by any TOC or private entity. The user-selectable information is presented through a Graphical User Interface (GUI), which could be supported by audible and/or visual alerts to allow operators to monitor the system while carrying on their other tasks.

- An Expert System (proposed for future installation at the TMS) will continuously look for anomalies in the collected information which might indicate a problem, determine the potential impacts of these problems on the region's transportation network, identify response strategies (in accordance with pre-approved baseline plans), and submit these actions to agency-specific TOCs for implementation. Response plans will be dynamic in nature in that the baseline response plans will be automatically tailored to real-time conditions and updated over the duration of the condition.

The ultimate goal of the regional architecture is to provide a mechanism whereby software and hardware elements can be implemented to allow the various subsystems and TOCs to share information and decision support via the TMS. As discussed herein, this architecture--for the regional and the VDOT portions of TMS--is built around real-time data distribution via a client-server model, integrated workstations utilizing a graphical user interface, geographical information systems (proposed for future), and decision support via expert systems (proposed for future).

Communication between agencies will be enhanced with the development of the regional capabilities of the VDOT TMS Center. The current TMS Center includes plans for remote access to specific data contained in the database and access to specific graphics designed as part of the system. TMS System requirements to promote the expansion to regional needs will include:

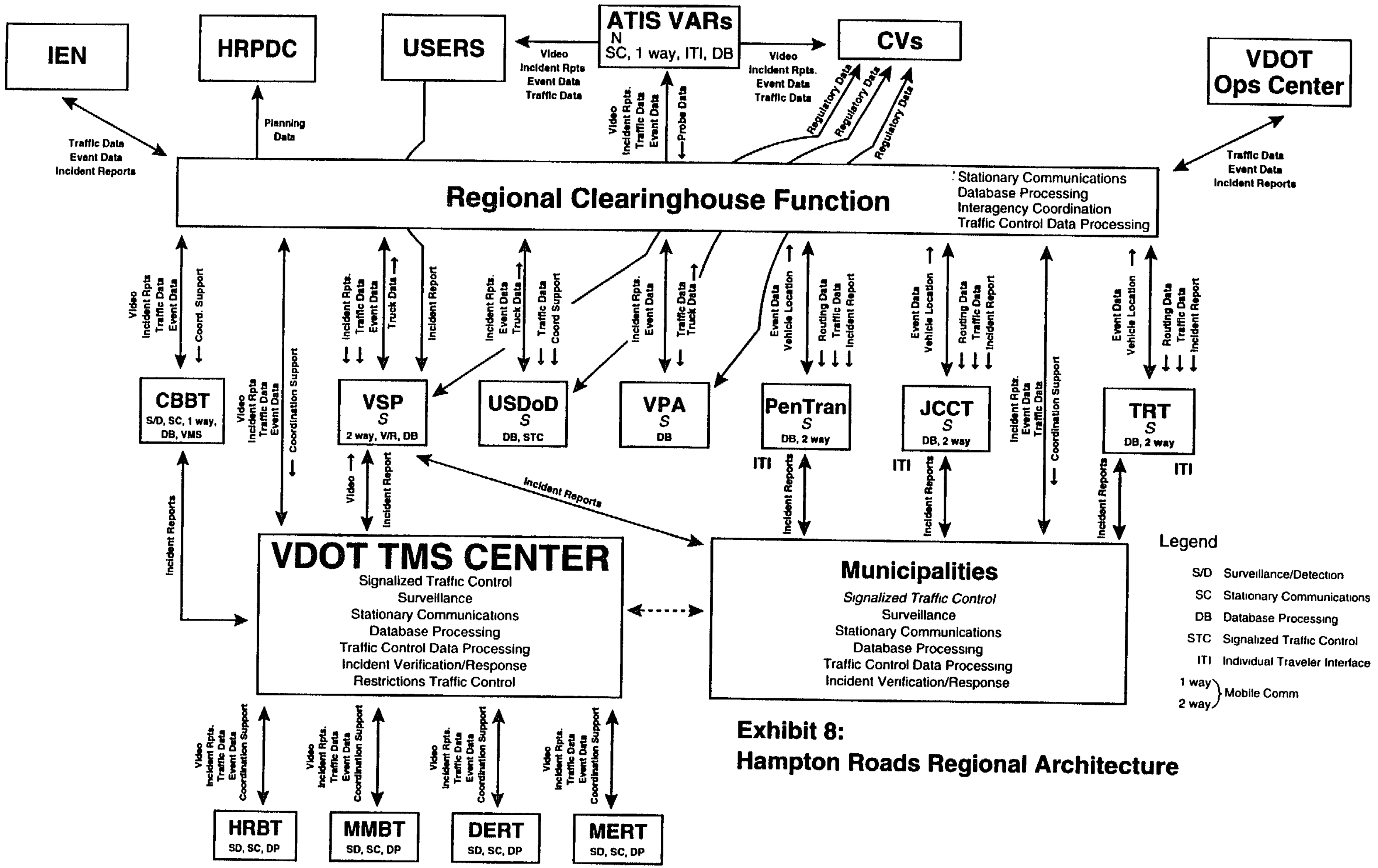


Exhibit 8:
Hampton Roads Regional Architecture

- Expansion of graphic features to include the major regional routes not part of the Interstate system.
- Expansion and promotion of remote access to databases by all local agencies and approved groups.
- Expansion of databases to reflect regional highway system and needs/uses of local agencies.
- Capability to upload and download regional traffic data and features considered part of the regional network.
- Development of Regional Operations Committee to promote and identify specific regional issues for implementation of the regional architecture plan.
- Implementation of workstation (containing fax and modem capabilities) and telephone communications in TMS Center for regional use. This workstation would be networked with the other workstations in the TMS Center but be dedicated to regional activities and limited in access of VDOT-specific data/ features.

The staging of these activities will occur consistent with other activities, e.g. expansion of regional communications system, development of arterial surveillance system, and coordination of the Regional Operations Committee.

Client-Server Model

The Hampton Roads Regional ITS network is expected to use the client-server model to facilitate the communication and integration between agency-specific systems and platforms, aid the development of new systems and interfaces, enhance the expandability of the system, and provide a common mechanism for systems to distribute and share information.

A client-server system is composed of one or more clients and one or more servers. In this system, a client gathers information required for queries or commands that will be presented to the server. It constructs queries or commands in a predefined language for presentation to the server. The client presents the command or query to the server and collects the results. The client will then often process the data that is returned from the server.

A server provides a service to the client. The nature of a service is very general, and it may include data retrieval, message distribution, data distribution, data processing and analysis, hardware interface and control, etc. A server responds to client queries and does not initiate communications with a client. Typical servers which meet these criteria include database servers, VMS interface servers, data gathering and acquisition servers, network printer servers, and network communications servers.

For the Hampton Roads Regional network (refer to Exhibit 9), a local system server/ interface (such as the IEN) is proposed to be added and connected to each agency TOC. The servers will interface with the agency system processors, gather information available from the local databases, convert it to a standardized global protocol, and interface with other workstations located at the agency-specific TOC's. This architecture allows each agency to maintain the appropriate degree of autonomy and control, while still integrating it into the overall ITS network.

At the heart of the network will be servers located at the TMS. In essence, the servers will act as bridges between the TMS and the agency-specific TOCs, thereby limiting traffic on the local area networks. Moreover, by using a standard network protocol and open systems design ITS data and traveler information will be transported throughout the region--between the TMS (regional) and agency-specific TOCs and private entities--using a combination of event-driven and direct data requests. It will be the "job" of each server to format this data for general transfer.

System security software must be incorporated into the Hampton Roads Regional ITS architecture to handle the potential conflicts between the responsibilities and liabilities of the individual TOCs and the needs to the regional TMS and the desires of private entities. Although the ITS design promotes data sharing between and among the many agencies, each local agency will remain in control of what "private" data is made available throughout the network. The system design must strike a balance between the regional needs and any restrictions imposed by the individual agencies.

Data security issues must deal with database access (read only), database changes (update), equipment control (variable message signs, signal timing plans), and system access (authorization of users). What privileges will be granted to each user or class of users must be determined, and a hierarchy of log-on procedures, and passwords, privileges must be established to protect the databases and to prevent unauthorized control and operations.

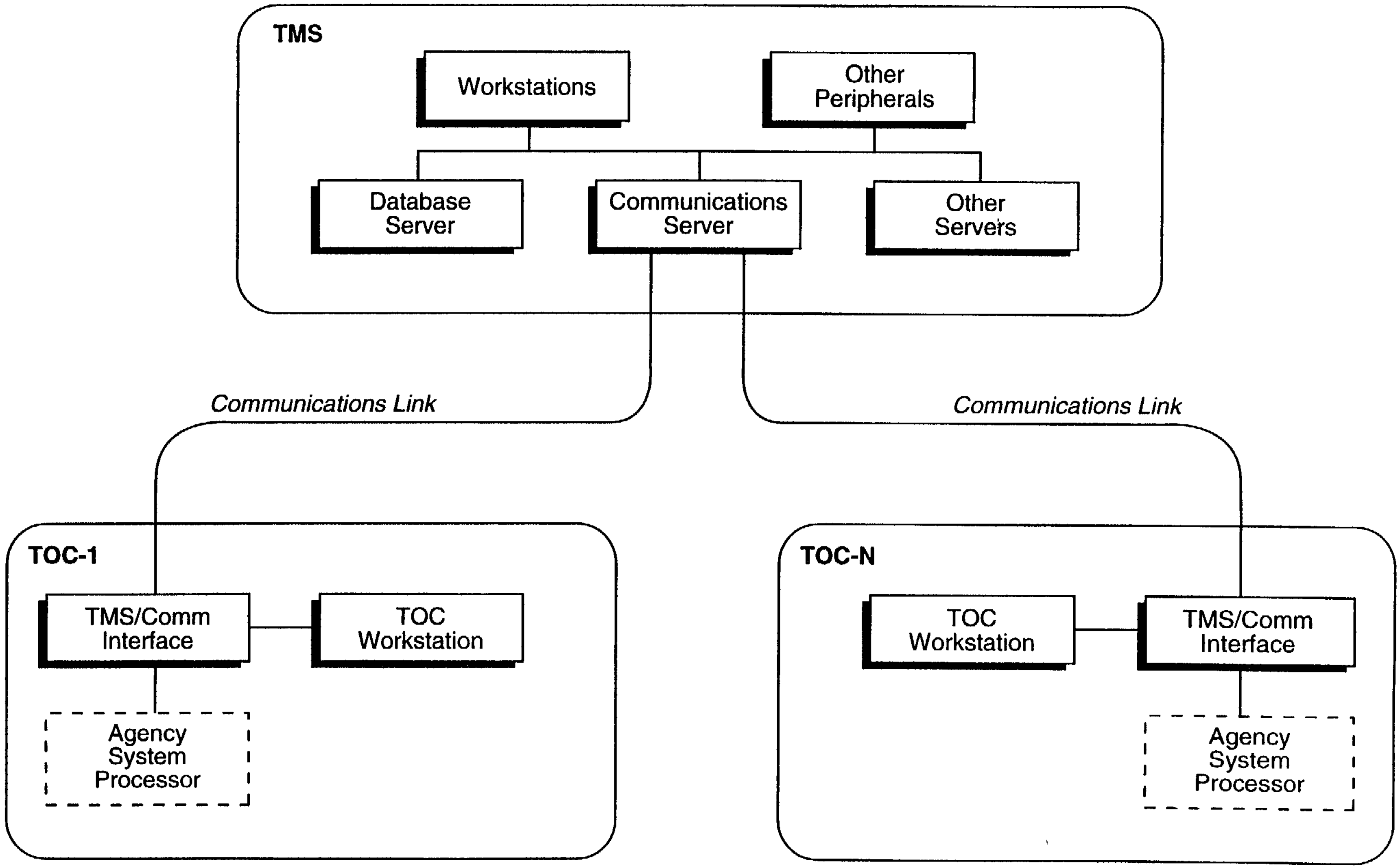


Exhibit 9:
Regional Configuration of Servers

Regional Coordination Needs: IEN

In meeting regional needs, several hardware/software options exist, given the planned regional architecture. Separate facilities (e.g., workstations, offices, software, etc.) may be maintained in or near the area provided for the VDOT TMS. Or, expansions to the existing planned VDOT systems may be developed. Or, a range of facilities between those levels of operation may be defined for specific functions. Given current needs, an additional workstation should be provided in the TMS Center for regional uses. This workstation would be tied (via the LAN) into the TMS network Expansion of other subsystems (e.g., CCTV, Traffic Database, VMS) would be provided to maintain the data and display capabilities of the regional roadway system and its environs.

The database server and the LAN file server (planned as part of VDOT TMS) will function as the central processor hardware--processing and storing data, distributing this information to the various workstations as required, and coordinating the overall activities of the various system components. The database information will include the static and the dynamic data. The static portions of the database will be much larger than the dynamic portions, as queries against static items are more complex and often require the transmission of more data. The dynamic parts of the database are updated frequently.

All primary system user access will be through workstations at each of the agency-specific TOCs. The primary objectives of the operator interface are to provide a more effective means for personnel to collect and categorize traffic information, download local key data, facilitate the interpretation of system information, and provide the ability to quickly formulate solutions to problems that arise. The Hampton Roads Regional network is proposed to use an integrated workstation format interface (e.g., IEN) to allow common information to be shared across the multiple systems and to provide a common interface to the network. The basic elements of such an interface should include:

- Map-Based - The graphic displays generated for the system should be geographically referenced with a map serving as the principal method for navigating through the system. System attributes and devices should be displayed as icons overlaid on a geographic representation of the system area with active ties to the database showing information about each element.

- De-clutter Techniques - Through the user of de-clutter techniques, the TMS user interface will be able to provide easily readable features at all levels of the system.

- Graphical User Interface (GUI) - The information presented on the workstation should be displayed in a combination of formats, including graphical, textual, and video, and will include interfaces to existing and future agency-specific systems.

- Third Party Software - The correct choice of platform (hardware/operating system combination) will open up the possibility of using familiar third party software for such tasks as system reporting through spreadsheet graphics.

The workstations would be high speed microprocessor based computer systems operating under a multi-tasking operating system (e.g., OS/2 or UNIX) with a full set of software development tools. The system should support an industry standard windowing environment with access to third party support software such as spreadsheets and statistical packages. The workstations should also support the selected WAN networking protocol and Database Management System (DBMS) in the client mode. Peripherals will include keyboard, mouse, and high-resolution color monitor.

Decision Support

The configuration of the Hampton Roads Regional transportation network is such that incident management procedures and potential traffic management strategies will undoubtedly affect multiple agencies. One of the primary functions of the regional TMS is to implement coordinated and pre-approved strategies and response plans to such events, including confirmation from the various transportation agencies that elements under their respective control have been deployed in accordance with the response plan. This decision-making process can be facilitated through the use of a decision support mechanism which accesses the full range of policy and pre-approved response information (static information), and compares it with real-time traffic information. The quick correlation of incident reports and observations can lead to a more rapid incident confirmation which, in turn, allows the appropriate response strategy to be established more quickly. Moreover, the decision support mechanism can expedite the deployment of the response plan (e.g, notifications, VMS, dispatch of incident teams, etc.).

Another consideration is system size. As the Hampton Roads ITS network grows to encompass the region, the amount of data and coordination of individual response plans will exceed the capabilities of staff if performed in a manual fashion. In addition, as there will be staff turnover, vacations, and other unplanned absences, it is necessary to construct a powerful decision support mechanism which embodies the normal decision-making "intuition" of these operators. To meet this problem and provide rapid response, it is recommended that an Expert System be employed in the longer term for decision support and incident management.

As an example, an Expert System for incident management provides operator decision support for several functions:

- Incident Detection and Verification - The system correlates information received from multiple sources, such as freeway sensors, police reports, current transit schedules, the location of incident response teams and cellular phone reports, to establish the presence of an incident. This information is formatted and presented to an operator for confirmation. The system may activate cameras and provide images to corroborate the information from other sources.

- Identification and Evaluation of Alternative Responses - With knowledge of the network, the devices available, and the basic pre-approved plans, the Expert System can recommend the appropriate responses to an incident such as signal timing plan changes, ramp metering rates, VMS message displays, and transit route or schedule changes; then present this information to operators for approval or modifications as may be appropriate. The Expert System can also help in executing the response plan by sending messages to the appropriate agencies to activate field devices.

- Checklist Procedures - The expert system will present checklists as an aid in reminding the operator of required notifications, actions, clean-up, and follow-up based upon incident type.

- Traveler Information - As part of the response plan, the Expert System can identify information to be transmitted to the media and other private entities.

TRAVELER INTERFACE NEEDS

SCOPE AND RECOMMENDATIONS

Traveler interface technologies provide the means by which the travelers (and soon-to-be-travelers) are provided with real-time traveler information regarding roadway, transit, and traffic flow conditions. This information can assist the traveler with planning his/her trip, selecting the optimum mode or route, and dynamic decision making during the trip so as to improve the efficiency and convenience of travel (i.e., enhance mobility). The extent to which the traveler accesses the available information depends not only on the timeliness and accuracy of the information, but also on the ease of access to that information. The applicable functions include: individual traveler interface, variable message displays, navigation, in-vehicle devices, as well as the surveillance, communications, and information processing functions.

Traveler information needs (En-Route Driver Information and Pre-Trip Travel Information) were identified by COMPARE as two of the top Priority User Services for the Hampton Roads Region. This concern reflects the unique mix of travelers in the area and the types of trip-making decisions they face. The target groups of travelers include:

- Tourists visiting the area whose primary interface with the system will be while driving, at information centers, and in hotels. Specific traveler interface technologies must deliver information that is predominantly tourist oriented (weekend, destination oriented, etc.).
- Commuters who reside in the area and travel to and from work every day. These travelers are available in their work place, homes, and in their automobiles and oriented to peak periods and all modes.
- Through traffic tbat is composed of people traveling through the area to another destination who desire to avoid local congestion or incidents. These people typically only contact traveler information while En-Route.

The delivery of traveler information is an appropriate role for private enterprise and well-suited for private-public partnerships since private entrepreneurs may be able to generate revenues for high quality information that can reduce public costs and, at the same time, apply entrepreneurial expertise in retailing and tie-ins with related commercial opportunities. However, special efforts will have to be made by transportation agencies to attract private involvement.

Traveler Interface Recommendations

In support of the Traveler Interface Plan, the following recommendations are provided. In the short term:

- Targeted VMS Expansion - Expand VMS system throughout the Region to provide service at freeway-to-freeway connectors and other decision points with special attention to "frontier" locations to address diversion of through traffic.
- Expanded and Upgraded HAR Coverage - Expand HAR system (including to AHAR) to complete coverage along Interstate system.
- Support Private Development of Interactive Kiosks - Test the effectiveness of interactive kiosks at several key public areas (including at rest areas in advance of Hampton Roads Region).
- Upgrade Dial-up Information System - Up-grade dial-up highway advisory telephone and encourage involvement of tourist industry and private service providers.
- Create Media Interface - Implement and encourage access to/by broadcast media and (radio and TV) add remote users to VDOT TMS bulletin board/graphics systems.

In the long-term, it is recommended that the coverage of these elements be expanded, capitalizing on new technology and, in the case of personal information, an aggressive public-private collaboration be fostered.

Plan Considerations and Components

Existing conditions/plans

Traveler Interface Technology applications are in various stages of development throughout the Region:

- Highway Advisory Radio (HAR) - Currently, there are eight HAR transmitters (used by VDOT) broadcasting in the Hampton Roads area to advise travelers of traffic conditions. Static warning signs with flashers (activated for special warnings) supplement the HAR. Plans are to upgrade this system to regionwide coverage in the near future. Current HAR installations are illustrated in Map 7 (Appendix C).

- Variable Message Signing (VMS) - VDOT currently uses approximately 20 portable and 39 permanent VMS units located throughout the Region to alert drivers of upcoming traffic conditions with plans to expand coverage along the Interstate system as surveillance plans are completed along the Interstate. The Norfolk Naval Air Station has several VMS units on its grounds used primarily to alert Navy employees of road or gate closures within the facility. A portion of the VMS coverage is the result of an informal agreement between the North Carolina Department of Transportation, VDOT, and the City of Chesapeake to provide a traveler information system for motorists to and from the Outer Banks area in northern North Carolina. Current VMS is illustrated in Map 7 (Appendix C)

- 1-800 Services - Currently, VDOT operates and maintains a l-800 service which is available to callers within Virginia. A caller from a touch-tone phone can receive- taped messages on current traffic conditions (e.g., current roadway time/travel delays, construction activities, roadway closures, etc.) about the Hampton Roads area's major transportation corridors, as well as for each bridge and/or tunnel. Similarly, the Hampton Roads Tourist Association and the major bridge crossing groups (VDOT) provide telephone access and reports to travelers either in a pre-trip or cellular phone mode.

- Commercial Traffic Reporting - Metro Traffic monitors, collects, processes, and transmits traffic conditions and information about the Hampton Roads area's roadway network to 27 radio and three TV station in exchange for air time (which it sells to commercial vendors). Data is collected from airplane surveillance and supplemented by VDOT, the police, and private callers. Metro Traffic's roadway information covers all of the Hampton Roads area, including bridges, tunnels, Interstates, major and minor arterials, and railroad crossings. This data is distributed to the radio and TV stations on a regular basis during peak hours and on an event basis during non-peak hours.

Standards and Coverage

To a large extent, the reliability and accuracy of the data collection sources will determine the success of all the traveler interface activities. In order to estimate link travel times, traffic and incident data must be collected along major routes and potential bridge and tunnel choke points. It is envisioned that the real-time traveler information for the Hampton Roads ITS network will, in the future, include the following:

- Travel times (and costs) between key points in the network--by route and by mode--reporting areas of recurring traffic congestion (as may be determined by various thresholds for volume and speed) as well as "unplanned" incident locations. Corresponding delays including "catastrophic events" which close the roadway or transit route (e.g., bridge failure, fire, clean-up of hazardous materials) and "planned" incidents-- construction or maintenance activities and the resulting lane restrictions and special events (parades, fairs, etc.) -- must also be included.

- Weather conditions which may impact traffic flow (e.g., snow and ice, fog).
- HOV lane status and other operational changes (such as one-way operations)
- Schedule adherence for PenTran, James City County, and TRT buses, and expected times of arrival.
- Traveler service information.

Most of this information will be obtained by the surveillance function elements discussed earlier, and processed by the local and central hardware elements. Regardless of how traveler information is provided, to be effective, the data must be timely, complete and accurate. Any route and mode guidance advice must be credible, and it must be perceived by the individual traveler as providing a personal advantage when followed. Otherwise, the information will be ignored. In general, for each inaccurate bit of information promulgated by the traveler interface elements, it will take numerous occurrences of accurate information to recapture the traveler's faith in the system.

The existing detection and surveillance technologies and systems designed principally for traffic management purposes provide the point of departure for the information necessary to support effective traveler interface. Depiction of these technologies and future plans are displayed in Map 4 (Appendix C). A description of these systems follows:

- Bridges and Tunnels - As discussed earlier, the bridge-tunnel systems contain a substantial surveillance network consisting of CCTV and inductive loops. Information from these surveillance activities should provide sufficient data to compute the travel time on the bridge-tunnels. At this time, the primary concern with using this data is the lack of a direct link to the Suffolk District TMS Center (or other operations center).
- Interstate - As illustrated previously, these regions already contain existing surveillance equipment (e.g., inductive loops, CCTV) over a portion of the system that should be adequate to provide the necessary roadway and traffic data for link travel time computations. Currently, about one fourth of the system has surveillance detectors in place, and the remaining sections will have surveillance in the near future.
- Major Arterial - Currently, there is a limited amount of surveillance equipment on the arterial system. Future plans will include continued expansion of the arterial surveillance system to support this and other traveler interface activities.

FUNCTION/TECHNOLOGY APPLICATIONS

The traveler interface elements are proposed to disseminate the information to travelers utilizing a variety of audio and visual techniques. These information techniques are planned to include components which are physically present along the roadway network; those external from the roadway (non-roadway based) which may be used to provide the traveler with pre-trip information, and in-vehicle techniques.

Variable Message Signs

The purpose behind variable message signs is to provide dynamic information regarding existing traffic conditions such that motorists can make intelligent route choices. Special applications are possible in the Hampton Roads Area focusing on both long-distance travelers and intermodal needs. Selected VMS-particularly those in advance of intermodal facilities--may be used to provide dynamic information regarding the availability of the facilities, e.g., park-and-ride lots, parking facilities, etc.

VMS should not merely be used to convey information that could also be displayed by static signing. Rather, these signs should provide timely and accurate information which reflect the current conditions, and which can be used by the travelers to improve their trip time. Variable message signs functions should be expanded to provide dynamic information to motorists regarding a variety of conditions, including:

- Congestion - Variable message signs can be used to warn motorists of congestion that lies ahead as a result of an incident, bottleneck, or special event. The VMS also can be used to provide warnings when unexpected queuing occurs in areas of restricted sight distance such as around a curve or over a road crest.

- Diversion - Variable message signs can be used to inform motorists of available or required alternative routes.

- Transit Operations - Variable message signs can be used at transit stations to provide schedule information (e.g., arrivals, departures, status), on platforms to identify the arrival time and destination of the next vehicle, and on vehicles themselves to identify the next stop and estimated time before arrival.

- General Guidance Information - Variable message signs can be used to provide directions and information on ways to obtain additional information through other means (e.g., radio>.

  Mainten[redacted]nd Construction Work Sites - Variable message signs can be used to warn motorists of lane closures in order to avoid abrupt weaving. End of queue warnings and alternative route information can also be provided to motorists approaching work sites.

- Roadway Status - Variable message signs can be used extensively to provide information regarding the operational status of highways.

The recommended VMS locations for the Strategic Deployment Plan is shown in Map 7 (Appendix C). In general, signs have been located in advance of freeway-to-freeway connections, on the approaches to and along those roadway segments which experience the greatest congestion and in advance of the exits for major traffic diversion points. On a short-Term basis, extension of the existing VMS system should include expansion of the VMS signing in advance of the freeway-to-freeway connections and at selected key points along arterial routes to and from the North Carolina border area. These devices should be placed in coordination with current North Carolina DOT efforts.

A Regional Reactive Routing System

A special immediate action program for traveler interface is recommended, focusing on early deployment of VMS at key decision points facing through and long distance travelers. Priority completion of VDOT's on-going effort in terms of VMS installations together with the addition of tailored HAR messages for a special strategic focus can provide an effective and visible program. Such a "regional reactive routing system" is also considered an ideal ITS operations test/demonstration corridor because it deals directly with the three main traffic issues which are addressed in the Hampton Roads area:

- Tourists who are unfamiliar with the roadway network traveling to and from the beaches in Virginia and North Carolina.
- Large volume of commuters traveling to and from the military facilities.
- Recurrent congestion problems on the I-664/Monitor-Merrimac and I-64/Hampton Roads Bridge-Tunnels.

Roadways have been evaluated with respect to how reasonable it is to access the alternate roadway/bridge-tunnel, the likelihood that they will be routes used by tourists traveling to the beaches, and the volume of traffic at each location. Selected routes are illustrated in Map 8 (Appendix C) (i.e., I-64, I-264, I-464, I-664) and extend to areas north and south of these points. As discussed earlier, most of the routes in the regional reactive routing system have surveillance systems in-place or plans for future installation. In addition, HAR and VMS are already located on, or planned for, a majority of the I-64 network.

The primary locations in the North Hampton Roads area where a traveler must decide which roadway/bridge-tunnel to travel are in the Hampton area, where I-64 splits into I-64 and I-664, and at the I-64/US 17 junction. In the South Hampton Roads area, there are several major roadways where a traveler entering the I-64 network must make a decision about which roadway/bridge-tunnel to travel. This decision is influenced primarily by existing traffic patterns and the distance one must travel to access each roadway/bridge-tunnel. For example, if a traveler enters the I-64 network at US-13 and I-664, it is only eight miles to the I-664/Monitor Merrimac Bridge-Tunnel, and it is 28 miles to the I-64/Hampton Roads Bridge-Tunnel. Even under extremely poor traffic conditions, it may be difficult to justify a 20-mile addition to an 8-mile trip. However, if a traveler is entering the network from US-17 (south of the Region) onto I-64, then it is 12 miles to the I-664/Monitor Merrimac Bridge-Tunnel and 24 miles to the I-64/Hampton Roads Bridge-Tunnel. A traveler could reasonably choose to drive an extra 12 miles, knowing that traffic on the I-664/Monitor Merrimac Bridge-Tunnel was very congested, while the Hampton Roads Bridge-Tunnel was operating smoothly.

A key aspect of the proposed regional reactive routing system is the provision of comparative travel times to key regional destinations. It is envisioned that the VDOT TMS Center will provide the information processing capabilities required by the system. The information collected from the surveillance system's components will be used to compute the average speed of the traffic along the various roadway links. Then, approximate travel times can be determined from this average speed calculation. The TMS's processing system should be capable of computing link travel times between all adjacent interchange locations within the regional reactive routing system . With these link travel times available, the TMS will be able to compute the travel time from any interchange in the regional reactive routing system across either of the two bridge-tunnels or the James River Bridge alternative. By using link travel times, a more accurate picture of the region's overall travel times will be established. The system will be more responsive to sudden changes within a small area of the regional reactive routing system.

On a longer-term basis, the freeway diversion signing and other VMS signing along other key arterial routes should be added. It should be noted, however, that this technology may be superseded by in-vehicle or on-person technologies, based on the successes of these programs.

Highway Advisory Radio

Another recommended method of providing information to motorists is through their car radios. Highway Advisory Radio (HAR) provides a relatively economical means of disseminating a significant amount of information on potential alternate routes or traffic conditions facing the motorist. This "one-way mobile" communications can provide more specific traffic information at key locations on an immediate basis to a targeted group of motorists than is possible through traditional commercially broadcast traffic reports or VMS. HAR is currently used to provide information regarding traffic conditions at the Hampton Roads Bridge/Tunnel.

The Short-Term Element of the Strategic Deployment Plan includes the installation of HAR to allow complete coverage of the Interstate system and other major facilities in the area. The recommended HAR locations for the Strategic Deployment Plan is shown in Map 7 (Appendix C). It includes locations that are in coordination with the North Carolina DOT's efforts to provide traveler information to motorists to and from the Outer Banks area.

As with the VMS, it is essential that the messages be timely, relevant, and consistent with one another. As HAR is expanded on a regional basis, it is increasingly cumbersome to accomplish this manually – especially if a multiple zone concept is required. For this reason, use of a common database is advantageous for automatically generating messages. HAR can utilize live messages, pre-selected tape messages, and synthesized messages based on information in the system database. This technology already is in use and is available from multiple vendors.

Highway Advisory Radio alternatives are substantially defined by their power and coverage. When properly maintained and installed, lo-watt transmitters have a broadcast radius of approximately 3-5 miles. New FCC rules permit HAR to be broadcast on any frequency between 530 kHz and 1710 kHz provided an FCC license is obtained. The FCC rulings have also opened up the former dedicated HAR frequencies -- 530 kHz and 1610 kHz – to commercial broadcasting, thereby increasing the potential for interference or possibly the loss of a license.

VDOT is currently testing a more effective low power system as well as a higher power approach that would provide broad area-wide coverage.

The technology selected to achieve the recommendations should be based on the results of the ongoing and planned operational tests. If successful, these units may be used, although the region-wide message flexibility with these units may be limited. Low-power Highway Advisory Radio has been developed as a means of tightly controlling the broadcast zone and thereby limiting interference from adjacent zones. Its broadcast radius (per transmitter) is generally limited to 500 feet to 1500 feet. By using this concept, a series of zones -- all operating on the same frequency -- may be established whereby unique site-specific messages may be transmitted to provide condition updates in advance of decision points. Along arterials or for special event needs (including construction/maintenance activities), low-power transmission systems can be successfully employed.

In the future, Automatic Highway Advisory Radio (AHAR) provides a method to overcome the need for HAR signing and manual tuning to the HAR frequency. The traveler information is the same as traditional HAR; the automatic part of the system is tuning the radio to the HAR frequency. The AHAR transmitter sends out a leading message, which is picked up by a special in-vehicle receiver when the vehicle enters the AHAR zone. The message automatically tunes the radio to the AHAR station and mutes any regular radio broadcast until the AHAR transmission is complete. This technology may become available in the near future.

Individual Traveler Interface

Telephone-Based Traveler Information System

Telephone based information systems can provide up-to-the-minute traffic and other traveler-related information in the form of voice messages delivered to motorists before or during a trip. As described earlier, a dial-in information system is already in place in a simplified form in the Hampton Roads area. However, the greater use of cell-phones in the Region has increased the potential value of these systems and the importance of information which is both more local and of greater reliability to serve all travelers (commuters, tourist, and through travelers). Automation and available software and the existence of private communication systems increasing make this a cost-effective way of providing traveler information.

Characteristics key to the proposed telephone based traveler information system include:

- Both traveler and tourist information provided
- Information is real time (up-to-date)
- Information is customer trip-specific (origin-destination-based)
- The availability of the information is widely known (public relations)

Additional enhancements could include such information as the "best" time for a tourist to arrive and depart on specific days of the week (based on historical data) and the installation of voice-responsive software, making the system safer for En-Route cellular callers.

Tie to Regional Database

In order for this program to be effective, real time information must be provided to the traveler. If an incident causing a major delay occurs within the roadway network, the telephone-based traveler information system's data bank must be updated immediately to reflect changes in the traffic conditions. This may be accomplished by tying the system directly to VDOT's TMS Center. In the near future, the TMS will be processing and disseminating data relevant to traffic conditions throughout the Hampton Roads area. A system processor could be set up at the TMS to analyze this data and provide relevant information to the traveler as the traffic conditions change. The system would provide not only information about traffic on a current route, but about delay times and alternate routing. The system should be capable of determining the travel times of the user-selected alternative routes and conveying this information to the traveler.

To provide pre-trip information, the center must also be equipped with the ability to store and analyze historic travel time data to advise potential travelers of typical travel times varying by day-of-week and time-of-day.

Customer-Responsive Format

A caller would dial in to obtain pre-trip information through an interactive network based on its current touch-tone format or as a voice-responsive system. A key feature of the upgraded system would be the expansion of the menu to include an origin-destination format providing Point A-to-Point B traveler information as selected by the caller. This information would be provided in terms of travel time advisories (as distinct from route conditions) thus accommodating the needs of tourists or through travelers unfamiliar with the Region's transportation network.

Other proposed traveler information additions may include:

- Visitor information (e.g., ingress/egress from the Norfolk Waterfront area or the Virginia Beach area).
- Tourist/recreation -related schedules and locations.
- Specific transit routes.

Technology Requirements

The available functions offered would expand substantially on those currently available and would require implementation staging as the data base, analytical capability and phone equipment are upgraded. A system-specific staging program should be developed in response to the following criteria:

- System Expandability or Future Growth - The system should be easy to expand through incremental additions of telephone line interfaces or application processing and storage equipment. The voice processor should be capable of updating voice messages by receiving instructions from the host application through a network.
- Voice Menu Design - The voice menu should be easy to modify, and should allow multiple access paths to available data. Studies have shown that different callers tend to interact with the system in different ways; not all users access data in a hierarchical, orderly way.
- Reliability - The traffic information available from the Traveler Advisory Telephone (TAT) system must be reliable in order to build and maintain public confidence in the usefulness of the system. The messages should be accurate, concise, and easily understood. Reliability of the TAT system equipment is also important. If the system is frequently down, busy, or otherwise unavailable to a caller, that person is likely to stop using the system.
- Concise Messages and Fast retrieval - The average call length is dependent upon message length and system response time. If length of time is short, then the system will be able to provide users with desired information more rapidly, and will allow the system to service a greater number of people. For these reasons, the design of the vocabulary database and voice menu are the critical issues in the TAT software.

- <u>Multiple Languages and Dialects</u> - These capabilities can allow broader range of motorists to make use of a TAT system.

- <u>On-Line</u> Update - The system should allow the updating of the message database and voice menus while it continues to process calls. This reduces system down time and allows callers to receive the latest information.

Information could be presented through the use of voice-responsive systems and voice-digitization techniques. Voice-responsive systems automate speaking voice menus to callers, prompt for caller inputs (touch tone), and translate the signals into digital data transmitted to the host (TMS) application that can then be utilized to announce synthesized or pre-recorded messages to the caller. Use of such technology would be necessary as the number of real-time and customer-specific responses increase.

A potential enhancement to the program might be an automated subscription service on which users are called during subscriber-defined hours to alert them of unusual congestion or delays on subscriber-defined routes and/or modes. It is envisioned that this service would be operated by a private entity who would be reimbursed by charging for the calls and related services, or via a public-private partnership.

<u>Information Kiosks</u>

Kiosks are becoming an important traveler information communications device and have been adopted by many transportation agencies. Kiosks allow travelers to access current data on road and weather conditions specific to a region, road maps, and current news regarding local events, Further benefits of kiosks lie in their availability to the traveler at traveler rest stops, the ability of a computer system to keep the data updated, and the ability of the kiosk to record user requests and reactions to the system that allow future modifications and enhancements which are responsive to the public.

An automated kiosk is a stand alone unit most commonly containing a computer terminal and some form of user interface (e.g., keyboard, touch screen). Automated kiosks are .a roadside interface in which the traveler must actually stop the vehicle to use, unlike any of the other roadside systems. Kiosks are typically installed in rest areas, visitor information centers, and truck stops. Although a kiosk could be installed in a completely stand-alone facility it is unlikely that a traveler would stop just to use the kiosk, for both convenience and safety reasons. When applied as part of an ITS system, maps of all routes to areas of interest can be housed on each kiosk's internal hard disk. This is static information which will change very infrequently. The kiosk database can also contain dynamic information, such as current traffic and weather conditions, which update through dynamic data updates from the ITS systems.

An experimental approach to kiosk development is recommended by incorporating two key concepts:

- **Identification of locations for maximum impact** -- The proposed kiosk locations for the Strategic Deployment Plan are shown in Map 9. In general, kiosks should be considered at regional airports, modal transfer stations, city halls, rest areas, air/army naval bases, and major shipyard generators and should be supported by private ventures.

- **Joint provision with other public and private sponsors** -- Given the limited public resources of the COMPARE members, it is proposed that kiosk development be limited to locations where strong "host" sponsorship is evidenced with a willingness to share development and operational costs.

The Clearinghouse Private Interface

The Hampton Roads Regional Clearinghouse functional network will be a repository for significant amounts of real-time information on traffic flow conditions and incidents, transit operations, and construction/maintenance activities. It is essential that the system (via the TMS) include several forms of interface for providing this up-to-the-minute data to private entities (e.g., radio and TV stations) and to the public, either automatically or upon inquiry. These capabilities are planned as part of VDOTs TMS system. A number of alternatives are planned, including:

- Teletype Network - Text information on current traffic flow conditions (e.g., average speeds, estimated travel times, congested areas, incident locations, etc.) would be periodically transmitted to dedicated printers or Fax machines at the various stations. One procedure is called "rip and read," where relatively final copy is provided. Another method is to provide traffic flow information in a standardized format which can then be used by broadcasters in preparing their traffic report.

- Workstations - This is similar to the teletype network, but the media stations have workstations and two-way communications which allow them to access the ITS regional system directly. This capability is currently planned by the VDOT TMS Center and includes a graphic display of the Interstate System and real-time operating speeds. This display should be upgraded to include primary arterials considered part of the regional highway network Other regional data (including video) may also be made available through the proposed IEN. A high-resolution color monitor is included for showing real-time graphic displays of conditions throughout the roadway and transit network (e.g., different colors representing various speed or travel time thresholds, and adherence of transit routes).

- Video Information - A video intertie with selected media is deemed valuable. CCTV images can be transmitted for those locations where incidents are present, or for selected freeway locations. The number of images available to the media would depend on the resources available to multiplex the data for transmission to the media and what level of manipulation (switching, number of monitors) the media outlet(s) would have available. A related issue is video communications between the system control center and the various media outlets. In all likelihood, this will entail compressed video (i.e., CODEC) over leased telephone lines.

It is envisioned that the private and public-entity interface will rely primarily on workstations and color graphics, with limited use of video. Moreover, as discussed earlier, the interface will be provided for the regional Clearinghouse function through VDOT's TMS. In terms of system design, it is important that the central hardware configuration of the regional Clearinghouse system include a sufficient number of communication gateways for these connections, and utilize industry-standard software and interface. Specific interface targets include the following:

- Cable TV - It is recommended that COMPARE explore the potential for cooperating with local cable companies which, with VDOT and the VDOT TMS Center, could establish a dedicated traffic channel on cable television. Currently, cable companies throughout the United States offer channels to announce events, local weather conditions, and advertising of regional attractions. A similar channel could be established to display information about traffic congestion, routing information, and tourist site accessibility. Traffic data could be automatically updated with information provided directly from the VDOT TMS Center. This information would benefit area residents that could view the information before leaving home, and tourists in the area that could access the information in their hotel rooms. Advertising by interested private sector organizations could help to fund the dedicated channel.

- Internet Link (via modem access) - An Internet link (via modem access> could also be established (e.g., separate access line, piggyback on l-800 line). This type of access would make it easier for employees to check traffic conditions prior to leaving their home or directly from their desk before leaving work The potential exists that this type of service may be included as part of the remote user access bulletin board currently being implemented in the VDOT TMS Center. This system would aid those with home computers and desk top computers at work having access to the Internet.

- FAX - A "FAX-on-demand" system could be implemented that faxes traffic information to interested travelers upon request. This system could be a dial-in system that uses a computer-generated algorithm to determine the motorists best route based on origin and destination points entered by a traveler, and then faxes these directions to the user. The "best route" determination would be primarily based upon historical roadway and traffic conditions; however, the system would also automatically receive traffic information updates that take current conditions (e.g., congestion, delays, incidents) into account. It is anticipated that the "best route" determined by the system would be based upon link travel times. The FAX system would be easily accessible to the public, so that anyone with a FAX machine could easily take advantage of the service (e.g., workers in an office environment, tourists staying at hotels with FAX services, potential travelers with a FAX machine at home). Calls could be made for a nominal user fee that could be billed in a number of ways (e.g., phone bill, credit card, separate FAX account).

- Teletext - Teletext technology uses the vertical blanking interval (VBI) portion of the TV channels bandwidth to transmit traveler information. The VBI is the black horizontal line located on the lower part of the TV screen and can be seen when the TV vertical hold knob is adjusted. Traveler information could be transmitted in conjunction with commercial TV channels or cable TV. In order to receive the transmitted information, the TV must be equipped with a world system teletext (WST) chip, the same device used for closed captions for the hearing impaired. These devices are becoming standard in the TV industry. This technology could be used to deliver pre-trip traffic information to travelers prior to their departure from the homefront. The information also could reach tourist in hotels through special information channels, such as Williamsburg's common cable channel for local advertisements and the "Story of a Patriot."

Future Technology

On-Person Systems (Future Technology)

On-person systems are those devices which are designed to be portable. Most of these devices applicable to an ITS were not originally designed for traveler information dissemination. They were designed as a personal communication device (PCD), a small, portable, wireless device for sending and receiving information. The most common examples of PCDs are the pager, which is capable only of receiving information, and the cellular telephone, capable of two way communications. The ongoing integration of portable personal computers and cellular telephone technologies is creating a device very suitable for use in traveler information systems. The PCD could access trip planning services, get information on current travel conditions, perform routing functions, serve as an AVL beacon, and even monitor vehicle condition.

PCDs have the potential to provide the user interface for almost all functions of an ITS: trip planning, routing, traveler advisory, route guidance, and emergency services. As the technology develops, all of these applications may become practical. With currently available technology, though, a PCD can serve the trip planning function (a portable personal computer), the traveler advisory function (a cellular telephone), and emergency services function (a cellular telephone). These devices are intended to be privately-owned devices with access to regional information systems, similar to capabilities planned by VDOT's TMS system.

In-Vehicle Systems (Future Technology

In-vehicle information provided to the driver can include current vehicle position, real-time traffic flow conditions (e.g., areas of congestion, speed limits, travel times) on the driver's route and on alternate routes, as well as weather information. This in-vehicle information can be presented to the driver in several ways, including:

- Map display - The various items of traveler information may be overlaid on a map display of the Region that includes the roadway network An arrow indicating the vehicle's location may be included when vehicle location information (as provided by AVL technologies) is available. The background maps are stored on a high density medium such as CD ROM.
- Text information and messages.

Techniques to display this visual information to the motorist while he is driving include self-contained CRT, vacuum fluorescent or LED units mounted in the vehicle, and projection of the information onto the windshield as a 2-dimensional holograph (i.e., "heads-up display"). In most of the current in-vehicle programs, the visual displays are being augmented with audio messages generated by synthesized voice. The audio messages eliminate the need for the driver to continually take his or her eyes off of the road.

Transmission of real-tune information regarding traffic flow and roadway conditions to the in-vehicle device requires an air-path communications medium such as an FM subcarrier, infrared beacons, satellite, or various RF techniques. Communications between the vehicle and an ITS-based system is generally two-way -- with the system transmitting data on traffic flow conditions to the on-board devices and the equipped vehicles transmitting data to the system for processing. These data may include individual vehicle speeds, travel times, and frequency of stopping. With the addition of vehicle identification, the equipped vehicles can also serve as traffic probes.

In North America, the private sector is the primary force behind the development of in-vehicle guidance/navigation systems. These various on-board systems are quite diverse in terms of the techniques and technologies used. As development and testing efforts continue, some of the approaches will likely be abandoned due to technological limitations, human factor considerations, or excessive costs. At some point, however, it will be necessary to develop and issue standards for in-vehicle navigation/guidance systems. Of critical importance will be the communications standards -- including network architecture, air-path medium, interface hardware, data rates and protocols, and message contents and formats. It is envisioned that this will be a major focus of the National Architecture effort.

PUBLIC/PRIVATE PARTNERSHIP

If traveler interface is to become sufficiently widespread and have a positive impact on congestion and mobility, significant resources, technology and entrepreneurship must be mobilized. The investment requirements, technology base and retail experience required are not consistent with current public agency resources or experience and, indeed, federal and VDOT policy are strongly oriented to supporting the development of public/private collaboration in the development of traveler interface services.

Roles and Hurdles

In essence, the public side (i.e., VDOT, local governments, transit agencies etc.) would collect, integrate, and analyze the public surveillance information. Interested private entities then would identify a paying market for travel information. Such entities will desire to access the available public information, augment it with other sources (consistent with the customer requirements and willingness to pay), market and disseminate the information and charge for the service.

There is a range of potential markets and dissemination technologies ranging from commercial broadcast networks to individual private phone-based systems. Each has different user target requirements and consequent data needs. While available information is sufficient for some commercial broadcast purposes, where sponsors are supportive, as demonstrated currently in Hampton Roads on radio and TV, individual interface and interactive systems which would offer an entirely new level of services to specific user groups (such as phone-based information) are not yet available.

At present, there are a number of hurdles to private marketing of traffic and travel information. These include:

- Current information is of limited value to travelers (not up-to-date, not sufficiently specific, coverage incomplete, unreliable).
- Traveler willingness to pay for this service not yet demonstrated.
- Public sector intentions are not clear.

An Evolutionary Approach

Hampton Roads provides some unique and positive conditions for the evolution of new forms of public-private partnerships in traveler information services including the mix of commuter, military business, through and tourist/visitor travel, the bottleneck-sensitive network configuration of bridges and tunnels, and the strong tourist market support potential.

Therefore, an evolutionary approach to public-private partnership development is proposed, building on the development of accurate and reliable traffic and travel data combined with an aggressive outreach to accommodate the start-up requirements of would-be private investors in traveler information services. Exhibit 10 illustrates the recommended approach.

In the short term, key actions would include:

- Expand detection and fuse publicly available traffic and travel data for the COMPARE Clearinghouse function.
- Make public data easily available in formats compatible with widely-used systems.
- Consider partnership arrangements with both private service providers and support from the tourism industry as stockholders.
- Explore alternative partnership opportunities through aggressive solicitation of opportunities focused on a range of dissemination technologies.

In the long-Term, as illustrated, key actions would include expansion of analytical approaches, dissemination methods and potential sponsors.

Exhibit 10
Proposed Public-Private Partnership Evolution

System Element	Short-Term	Long-Term
Data (detection)	• Existing bridge and tunnel D&S • Private aerial • Police	• Expanded arterial D&S • Historical files • Vehicle tracking • AVI tie-in (bridge and tunnels)
Fusion	• TOC (contract for service) • Manual	• Simulation/prediction • Automated • Expanded menu
Dissemination/Access	• Dial-up phone/cell phone • Feed to TV/CATV • VARs • Request fax	• Kiosks, rest areas, hotels • In-lodging CCTV • In-vehicle • PCD • FM subcarrier
Charging/Revenue	• 800 Number • Value-added to phone subscription • Advertising	• Affinity advertising • VAR service addition • Smart card
Sponsorship Roles	• VDOT/NCDOT • Tourism/lodging industry • AAA, travel agencies	
Marketing	• Destination (tourism bureaus, chambers of commerce) • VDOT/NCDOT	• Affinity sponsors
Additional Functionality	• HAR/VMS	• Dynamic route signing • Commuter oriented element • In-vehicle guidance

TRAFFIC CONTROL AND MANAGEMENT NEEDS

SCOPE AND RECOMMENDATIONS

The Priority User Services typically require a traffic control or demand processing requirement to effectively achieve their objectives. As such, traffic control and management strategies serve as a primary function to the User Services. This functional area includes management and control strategies that may be implemented to provide improved efficiencies on the roadway and transit network, reduce or spread out demand, enhance traveler safety, and improve commercial vehicle operations. These strategies may be implemented for recurrent conditions (e.g., peak period traffic congestion) as well as non-recurrent (e.g., highway incidents or special events) conditions. The applicable functions include: signalized traffic control, restrictions traffic control, as well as the surveillance, communications, and information processing functions.

Traffic Control and Management Plan Recommendations

In support of the Traffic Control and Management Plan, the following recommendations are provided. In the short-term:

- Expanded Signal Systems - In most areas of the Hampton Roads Region, traffic control systems exist. To enhance the system and coordinated control capabilities in the Region, these systems should be expanded to include all signals along major arterials or routes under each agency's jurisdiction. Possible exceptions may include signals that are currently isolated in operation with little or no change for coordination with other area signals in the near-term. It is also recommended that these signals be upgraded to be part of closed loop or central control operation to provide intersection monitoring capability as well as the ability for quick and efficient timing plan changes. Also, a new closed-loop system for the Williamsburg area is proposed.

- Expanded Signal System Capability - In addition to expanding the number of signals under system control, an expansion in the flexibility of the signals to service the traffic demands should be planned. Where optimized timing plans may have been developed for the AM peak, PM peak, and noon peak, plans should also be provided for other intermediate periods where traffic demands require a more adaptive plan. Similarly, the signal system's capabilities should be enhanced to provide for traffic responsive capability. With traffic responsive control, more flexible signal timing for variable traffic demands throughout the Region will result.

Finally, to enhance the flexibility of the signal systems, emergency vehicle preemption capability should be provided along specific regional corridors in the Region.

- Integrated Systems - To coordinate traffic operations across jurisdictional boundaries, integration of operations at these boundaries and the adjacent areas should occur.

- Incident Management - To more fully meet the incident management needs of the region, several activities are recommended. They include:

  - Implementation of the #77 cellular call-in number for highway incidents.
  - Co-location of State Police and VDOT and other key agency staff at the VDOT TMS Center during peak periods.
  - Implementation of an automated incident detection algorithm for the Interstate system.
  - Continuation with the installation of regionwide surveillance systems (in particular, CCTV).
  - Development and maintenance of computerized lists (readily available) of incident and emergency responders to incidents on a regional basis.
  - Approval of the traffic diversion plans for the region by all impacted parties.
  - Construction of accident investigation sites (pads) added as part of Interstate reconstruction projects.
  - Development and maintenance of an incident logging process for all major incidents as part of the Regional Clearinghouse function.

In the long-term, it is recommended that these programs be expanded as growth and expansion occurs throughout the Region. In addition, the following programs should be added:

- Travel Demand Management - Implement ramp metering systems along the Interstate to control traffic demands along the freeway corridor and through the Region. This recommendation should be implemented in a staged approach, concentrating on the highest levels of traffic activity.

- Incident Management - First, implement an automated incident detection algorithm for urban arterials and other major regional highways in the area. Second, with the implementation of GIS, CADD, and expert systems in the VDOT TMS, test and implement a traffic diversion algorithm/procedure for the regional highway system.

Plan Considerations and Components

Existing Conditions/Plans

Various levels of traffic control and management strategies exist in the Region. They include:

- **Signalized Intersection Control** - Most municipalities in the Hampton Roads area already have, and operate individual signal systems. The majority of the signal systems in use are referred to as closed-loop (or distributed systems). These systems distribute the control capabilities among three levels -- local controllers, on-street masters and a central microcomputer within the local agency jurisdiction. Little or no coordination between jurisdictions exist.

  Currently, these existing systems operate in what is referred to as "Time of Day/Day of Week" (TOD/DOW) mode. Under this mode of operation, fixed timing plans are called up for fixed time periods. Thus, the same timing plan is called up regardless of the actual traffic conditions. A feature that is available with several of the closed-loop systems is a mode of operation that is referred to as Traffic Responsive Operation (TRS). When operating in a Traffic Responsive Mode, the signal system implements a timing plan (from a group of pre-established plans) that best suits the actual traffic conditions as measured by sensors in the roadway. This provides for a more efficient traffic flow by having the timing plans more clearly reflect the traffic conditions.

  Another signal system-related control strategy that exists on a limited basis in the Region is emergency vehicle preemption. Many of the municipalities in the Hampton Roads Region that have signal systems make use of preemption equipment for isolated groups of signals. The majority of the preemption equipment utilize the "Opticom" system by 3M. With this system, emergency vehicles are fitted with special strobe lights. Sensors at the intersection detect the light from the strobes and places a preemption call to the local controller. Other preemption systems which exist include hardwire systems. With these systems, the preemption call is made to a group of signals along a predetermined route(s), e.g., at signals in front or adjacent to a fire house.

- Incident Management - The Virginia State Police and the Virginia Department of Transportation are in the process of establishing a highway emergency number (#77) whereby motorists can report highway incidents along the Interstate to the Virginia State Police communications center in Norfolk. Currently, highway signing along the Interstate system advertises the use of the '911' emergency call number, which is a central number for all emergency types in the area (including highway incidents along non-Interstate highways). Other means of incident detection used in the Hampton Roads Region include: automated incident detection (limited to the major bridge and tunnel facilities operated by VDOT), commercial traffic service (i.e., Metro Traffic flying the area during peak hours and other key periods and relaying to TV/radio stations and the respective police agencies), and service patrols operating along the HOV-lanes of the Interstate system. Limited means for incident detection exist along non-Interstate highways, i.e. arterials.

Closed-circuit television (CCTV) is planned to be used in VDOT's freeway management systems for the purpose of incident verification along the Interstate system. It is currently used in this manner at the bridge and tunnel areas where the CCTV technology exists. Cameras installed or planned to be installed along segments of the freeway will transmit video pictures back to the VDOT TMS Center. The purpose of CCTV is to rapidly confirm a suspected incident (as reported by detection algorithms or other detection means), to verify the nature of an incident, and to assist responders in quickly determining the appropriate course of action.

- Travel Demand Management - Travel Demand Management programs consist of technological activities in support of policies and regulations designed to mitigate the environmental and social impacts of traffic congestion. These type programs are active in the Hampton Roads Region, sponsored by local, regional, and state funds. Such programs cover a broad range of actions to encourage the use of high-occupancy and non-motorized modes of travel, discourage peak hour travel and long commute trips, reduce the total number of person trips made by single-occupant vehicles (SOVs), and improve flow conditions. It includes the generation and communication of management and control strategies through the use of advanced technology.

  Current Travel Demand Management programs in the Hampton Roads Region include: transit and paratransit services provided by regional transit agencies: TRT, PenTran, and James City County Transit; rideshare programs operated by the two transit agencies (TRT, PenTran); a van leasing program for Vanpools; park-and-ride lots using both leased and publicly owned space; employer sponsored fare subsidy programs; marketing programs; and HOV facilities.

Standards and Coverage

The standards for application of signal-related strategies are based primarily on the use of existing equipment systems, upgraded to meet the expanded demands of the system. In several cases, this expansion will extend from a total of three signals under system control to over fifty intersections under system control for a jurisdiction, requiring implementation of several master controllers and, perhaps, an additional central microcomputer for a specific jurisdiction.

The coverage of signal system-related recommendations include the control of all intersections regionwide that are part of the regional highway system. In this way, traffic operational improvements along these highways and which may impact regional operations can be more easily facilitated.

Strategies related to incident management and travel demand management-related programs are considered regionwide and will have similar impacts to the regional transportation system.

FUNCTION AND TECHNOLOGY APPLICATIONS

In providing for regionally-responsive operation of the area's traffic signal systems, several recommendations are given. These recommendations are based on the premise that the local agencies will maintain control over the traffic signals under their jurisdiction. A regional orientation will be introduced through coordinated efforts to operate the signal systems in manners favorable to regional traffic needs. Cooperation by the local agencies and the VDOT in providing this coordination is necessary.

Signalized Intersection Control

Signal System Control

As a point of departure, existing local signal systems should be expanded to monitor all signalized intersections in the area. As a result, all signalized intersections under each agency's jurisdiction will become part of the local agencies' computerized signal system. The advantages to this program include the ability to readily make timing changes as needed to assist regional traffic demands (such as for traffic diversion purposes, etc.), the capability to monitor the status of intersection malfunctions that may be detrimental to regional operations, and the need to provide coordination/ monitoring in or near jurisdictional boundaries.

Special priority should be placed on implementing a signal system for the Williamsburg area. Currently, all signals are isolated or controlled under a master located in the field. In order to provide greater flexibility and to monitor the signals in its area, a signal system should be added.

The capabilities of existing and planned signal systems to utilize or add the traffic responsive features of the systems should be expanded so that the systems are able to use traffic flow measurements from the field and select traffic signal plans based on the measured traffic conditions. For most of the closed loop systems in operation for the Hampton Roads Region, this capability exists and may not be utilized. For these systems, additional signal timing plans should be developed to suit the area's needs. For systems lacking the traffic responsive feature, plans to obtain the feature or similar capability should be made. In the interim, additional timing plans should be developed for daily and special weekend timing needs (by time of day/ day of week considerations) to better reflect the traffic demands in the area.

Signal Pre-emption

While signal preemption exists at isolated locations throughout the Hampton Roads Region, plans by most local agencies in the area are to expand the system of emergency vehicle preemption capabilities. The philosophy of emergency vehicle signal preemption is to increase safety and/or efficiency through providing a more controllable traffic operation. Preemption results in signal indications that provide or extend a clear path (i.e., green indication) for the priority vehicle, thereby enforcing the clearance of cross street traffic from the vehicle's path. This positive form of control increases safety and reduces the delay to an emergency vehicle. The reduction in response times, along with the potential to save lives and property, is a benefit that has convinced many communities to invest in preemption. At the same time, signal preemption interrupts a signal cycle, and consequently, may increase overall vehicle delay. To achieve favorable benefits of such a system on a regional basis, regional use of the system is recommended. Map 10 (Appendix C) defines the corridors in the Hampton Roads Region where emergency vehicle preemption should be expanded. These corridors are defined based on corridors displaying high levels of accident activity and congested corridors. This recommendation represents improvements for the short-term period.

In addition to emergency vehicle preemption, transit vehicle priority should be reviewed for application in the longer term future. While the justification for this improvement may not be feasible at this time or in the short-term, it may be justifiable in the longer term.

Inter Jurisdictional Coordination

Signals between jurisdictions and at other boundaries need to be coordinated. In many cases, the coordination will require two bases. First, institutionally, the agencies will need to select a common cycle length and offset/yield factor for these areas. This may require review of current data and optimization to assure favorable parameters are selected. Second, the physical interconnection/ coordination of the boundary signals will need to occur. This physical means of interconnection can occur in several ways depending on the hardware and software capabilities, e.g. coordinating system clocks, developing a special software program to guarantee coordination at boundary points, and physically tying in boundary signals to one jurisdiction or another.

Incident Management

Incident Detection/Verification

Incident management was identified as a high priority ITS User Service for the Hampton Roads Region. The Strategic Plan includes automated surveillance (i.e., detectors) as discussed earlier, and automated incident detection and closed-circuit television for verification. The Interstate system for the Region is being instrumented with detectors at nominal 1/2-mile intervals, thereby providing increase coverage. The purpose of the automated incident detection functions is not to necessarily improve the detection time, but rather to ensure that no incidents are missed along the roadway network.

As a key effort, the program for implementation of the #77 highway emergency number should be advanced. It will facilitate reduced incident detection times for the region. Automated incident detection will also improve detection time by examining real-time traffic data (e.g., volume, occupancy, speed); detecting any "abnormal" changes in these traffic flow measurements possibly indicating an incident; and identifying the location of the occurrence. Algorithms for automated incident detection typically consist of a set of traffic measurement features and a corresponding set of preselected, comparison thresholds. When the traffic flow parameters, measured in real-time, exceed their corresponding thresholds for a user-defined period, an incident is indicated. Several algorithms are being considered and will be tested by VDOT. A discussion of several key algorithms is contained in the document entitled "Assessment of ITS Technologies" (NEC).

Along non-Interstate highways, available incident detection methods are similar to those used along the Interstates, i.e., cellular call-ins to '911' or the police and traffic reporting services (Metro Traffic). In the longer-term, incident detection algorithms for arterial networks may be feasible and should be implemented, augmenting the planned surveillance system for the regional highway (non-Interstate) system. In addition, CCTV is proposed in the short-term at selected locations around the Hampton Roads Region (see Map 4), where either congested corridors or high-accident locations, have verified the need for added traffic surveillance. The CCTV system underway and planned along the Interstate system will also provide this capability at the approaches to the Interstate system.

Full CCTV coverage (i.e., no "blind" spots) is planned along the Interstate system and along key segments of non-Interstate roadways. These camera assemblies--will be installed on poles or on buildings as the opportunity exists, at 314 to l-mile intervals depending on the horizontal and vertical alignment of the roadway. These assemblies are planned to be in place in the short-term period (0-5 years).

Incident Response

To speed the incident response times, the "call list" of responders by incident type for regional use should be computerized and made accessible for each agency's needs. Where feasible (VDOT case, for example), the list should be combined with computer-aided dispatching (CAD) capabilities. In addition, operational tests for using AVL systems on emergency vehicles should be evaluated to determine the effectiveness in further reducing incident response times.

Traffic Handling

Many agencies have developed and formalized traffic diversion plans should traffic conditions warrant their use. VDOT has developed traffic diversion plans for Interstate incidents in the Hampton Roads Region. These plans, once approved, should be computerized and entered onto the Regional Clearinghouse database system. An alternative to the use of pre-selected plans which is recommended in the Hampton Roads Region for the longer-term, is the use of traffic diversion algorithms.

One method of traffic diversion algorithms involve comparing travel times from each potential diversion point to an appropriate destination within the network (e.g., CBD). If the estimated travel time on the primary route exceeds a preset user-enterable threshold, then this primary route travel time is compared to the estimated travel times for the alternative routes. If the travel time for the primary route exceeds the travel time on the alternative route by a preset, user-enterable, time saving factor, then diversion level 1 is eligible for selection. This comparison process is repeated for successively higher priority diversion levels until a diversion level fails to show the minimum time savings; at which point the appropriate messages -- corresponding to the last diversion level satisfying the required time savings -- are displayed on the VMS, broadcast over HAR, and fed to the media. These motorist information messages may range from advisory (for the lowest diversion levels), to suggestive, and even directive depending on the levels of congestion, travel time differences, and other factors such as a roadway closure.

Prior to the estimate of travel times, the primary and alternate route volumes and speeds are adjusted to account for the traffic volumes expected to be diverted by the system. Similarly, the primary and alternative route travel times are also adjusted. This redistribution process is based on a table of expected diversion compliance for each level. Each value in the table represents the percentage of primary route traffic expected to be diverted to the alternate route by the associated diversion level message plan In general, as the diversion level increases, the percentage of the traffic expected to divert also increases.

To properly implement a diversion using automated procedures, it is necessary to have accurate data and sound base mapping (typically GIS-based) on the primary and secondary routes to properly predict travel times for diverted traffic. In the case of the Hampton Roads Region, the secondary routes in many areas are comprised of local arterial roadways. It is planned, as part of the regional surveillance plan, that the traffic management and surveillance system extend to the regional arterial roadways. Currently, VDOT is in the process of gaining approval on base diversion plans for the major Interstate travel corridors in the Hampton Roads Region. Automating the trip diversion planning process, using real-time traffic data is recommended as a longer-term goal for the Region.

Accident investigation sites are relatively low cost, specially designed areas situated near or next to the freeway. Their purpose is to provide a safe haven for motorists, service patrols, and police to exchange accident and/or license information. They can also provide a place where motorists may contact and wait for help, or deal with emergency conditions without interfering with the normal flow of freeway traffic. As Interstate re-construction occurs, the placement of accident investigation sites along the Interstate should be reviewed.

Inter-Agency Cooperation

Incident management is a multidisciplinary activity requiring information sharing and collaborative actions. The primary responsibilities for initial response and on-scene management belong to the State and local police, with the Virginia Department of Transportation and other local agencies providing assistance. As such, co-location of these parties, primarily during major incidents, should be encouraged. The VDOT TMS Center is a feasible location. Other entities to have legitimate duties at the incident scene, include:

- Local fire department and ambulance services, particularly when an incident involves fire and/or injuries.

- Local public works/transportation departments, particularly when traffic is diverted onto local streets.

- Environmental agencies, particularly when hazardous wastes and/or toxic materials are spilled.

It is also important that other transportation agencies within the Hampton Roads Region be informed of the incident and its impacts so that they can "respond" in an appropriate manner.

ITS technology, as is being recommended for the Region, can be an extremely effective tool; but it is not an end in and of itself. Without the cooperation, coordination, and commitment of all parties, the traffic and incident management program may never be successful, regardless of how much technology and funds are expended.

The regional architecture described earlier provides the technical and institutional mechanisms for developing the necessary coordination. As noted therein, one of the functions of an Operations Committee, with support fiom TMS staff, will be to maintain incident response plans as conditions dictate. Incident response plans/strategies should be developed for each and every segment of the regional network, and should include the following:

- Affected highway segment/direction

- Responsible agencies and contacts

- Participating affected agencies

- Levels of implementation (i.e., different strategies will be required depending on the time of day, the number of lanes closed, and the estimated duration of the incident)

- List of objectives (e.g., local diversion, regional diversion, traveler advisories, on-site flow control, etc.)

- A list of actions associated with each objectives and implementation level (e.g., notifications and how accomplished, VMS messages, media feeds, set up of diversion routes, etc.)

These strategies will comprise of a set of rules which can be input into an Expert System (future) to facilitate their implementation and for overall decision support.

Travel Demand Management

Ramp Metering

Ramp metering represents a traffic control strategy aimed at controlling the demand into the system. Ramp metering controls the rate at which vehicles enter a mainline freeway such that the downstream capacity is not exceeded, thereby allowing the freeway to carry a maximum volume at a uniform speed. By controlling traffic at the on-ramps such that the freeway's throughput is maximized, more vehicles can enter from the ramps than if the mainline flow was allowed to break down. Another benefit of ramp metering is its ability to break up platoons of vehicles released from a nearby intersection. While the mainline, even when operating near capacity, can accommodate merging vehicles one or two at a time, queues of vehicles attempting to force their way into freeway traffic create turbulence and shockwaves that cause the mainline flow to break down Reducing the turbulence in merge zones can also lead to a reduction in the sideswipe and rear-end type accidents associated with stop-and-go, erratic traffic flow.

In the Hampton Roads Region, as congestion along the Interstates and freeways increases and to augment the incident management program for the area, ramp metering on a systemwide basis should be implemented. While ramp metering is not planned for the short-Term, steps to assure the successful implementation upon its need should commence immediately. Several of these steps are outlined in the material presented earlier. However, it cannot be over-emphasized that the ramp metering issue represents a major public relations issue. It requires the cooperative agreement of all involved parties to ensure its success. Education of the public on the value and benefits to be gained with ramp metering will greatly assist in this effort.

In the longer term, ramp metering is proposed at all Interstate ramps in the Hampton Roads Region This system is displayed on Maps 11 (Appendix C). On a priority basis, the ramp metering plan, as envisioned at this time, would be staged in the following manner.

- Priority 1- Route 44, I-64 (south of Hampton Roads Bridge Tunnel to Route 44), and I-264 (east of Portsmouth);

- Priority 2- I-64 (south of Route 44 to I-464), I-464, I-264 (from Tunnel to I-664), and I-64 (north from Hampton roads Bridge Tunnel to north of Mercury Boulevard); and

- Priority 3- I-64 (from I-464 to I-6641, I-664, and I-64 (from north of Mercury Boulevard to north of Williamsburg).

Ramp metering rates would be based on the review of current ramp volumes and using the guidelines and limits discussed earlier. While alternative metering modes exist, the pre-timed mode should initially be implemented. After public acceptance of the concept is gained, more adaptive modes (traffic responsive) may be tested. Also, all proposed ramp reconstruction designs should incorporate in their design the feasibility of ramp queueing requirements and the need for an HOV bypass lane or multi-lane ramps to be metered.

Demand Management Operations

Of the many potential Demand Management Operations support projects, two projects relate distinctly to the Hampton Roads area. The Route 44/I-64 HOV facilities form the core of what has the potential to be a regional system of HOV-preferential treatments. The Third Crossing Study is considering an HOV option which could further boost the efforts in the Region to improve upon the low average auto occupancy (1.12) of the region. By integrating the HOV facilities in regional traffic control, greater HOV preference could be given through:

- Automated vehicle occupancy determination.

- Controlled access only to those vehicles meeting the HOV occupancy requirement (aiding HOV enforcement)

- Dynamic management of the HOV restriction. This latter ability is a key aspect of the operation of Northern Viiginia's HOV system, where HOV restrictions are dropped on occasion as a means of incident management.

4. OPERATIONS PLAN

The purpose of this section of the Report is to highlight the Operations Plan for implementation of the short- and longer-Term ITS activities recommended for the Hampton Roads Region, The Operations Plan includes the priority and timing for implementation, institutional roles and related issues, resource requirements in terms of system costs and potential funding sources, personnel implications and means of implementation and key start-up activities.

Exhibit 11 defines the specific short and long-range activities described in earlier sections of this Report. Following is a discussion of several key issues related to the Plan.

INSTITUTIONAL

As indicated on the exhibit, VDOT and local agencies are the principal implementers using their own staff or contractor support for actual implementation -- depending on whether the element is part of the state or local agency responsibility. In some cases where the division is "fuzzy" (as in interagency exchange networks), there are opportunities for policy discretion by VDOT.

Public funding may come from several sources including: federal aid oriented to urban and congestion problems (such as Congestion Management and Air Quality (CMAQ) and Surface Transportation Program (STP funds), 100% state funds that may be part of new construction or reconstruction of other elements of the state system; or from other new arrangements made between state and local government to facilitate implementation of ITS. These issues would be addressed both in the VDOT's State Transportation Improvement Program (STIP) as well as in the development of the Transportation Improvement Program (TIP) by HRPDC. Parts of the program may be eligible for special federal aid in the form of "operational tests" where new technology or institutional arrangements are being tested for applicability and resourcefulness.

Project funding and management may also be provided by the private sector. There is a clear national trend in ITS--encouraged by USDOT--to structure ITS development programs to take maximum advantage of the potential of private sector entities such as communications providers, technology vendors, and private information service providers to provide investment capital, resource-sharing potential, special technical expertise and consumer service experience.

Exhibit 11
COMPARE Implementation Plan
A. Short-Term Projects

Function	Implementation Level - Activity	Estimated Cost ($)	Added Personnel Requirements	Added Equip. Requirements	Implementation Time (Period)	Means of Implementation	Funding Source	Institutional Issues/Interim Actions/Other Comments
Surveillance	1-Coordinate Bridge and Tunnel Data from Bridge/Tunnel Authorities with VDOT/Regional TMS (Software Development).	$75,000	None	None	Year 1	Software development by contractor	VDOT	Requires communications medium be available between sources (including VDOT/Regional TMS) VDOT currently has plans to implement this activity.
	1-Extend VDOT Surveillance Systems along Interstate in Region.	$10,320,000	4 Maintenance Staff	CCTV , Type 170 processors, detectors, piezo sensors, weather/environ-mental sensors	Year 1-5	Contractor	STP, VDOT, CMAQ, Public-Private partnership Operational Test (with new technology)	Assumes software capabilities exists to manage/process data. Expand from existing surveillance system along Interstate. VDOT currently is committed to a portion of these activities. Be "open" to new technologies. (Assumes primarily inductive loops)
	1-Encourage Adoption of "#77" Cellular Call-In Program Regionwide.	$100,000	1 add'l. State Police Staff	None	Year 1	VDOT/State Police Staff	VDOT	Requires implementation of static informational signing and public information effort. VDOT currently is working to implement this activity

Exhibit 11 (Cont'd)
COMPARE Implementation Plan

Function	Implementation Level - Activity	Estimated Cost ($)	Added Personnel Requirements	Added Equip. Requirements	Implementation Time (Period)	Means of Implementation	Funding Source	Institutional Issues/Interim Actions/Other Comments
Surveillance (Cont'd)	2-Extend/Upgrade Arterial Surveillance System along Regional/Arterial Highway system.	$20,600,000	2 Maintenance Staff	Type 170 processors, system processors, loops/microwave/radar (where applicable), CCTV (limited)	Year 2-5	Contractor	STP, VDOT, CMAQ, Public-Private partnership, Operational Test with new technology, Local Agency	Assumes software capability will exist to manage/process data. Be "open" to new technologies (Assumes primarily inductive loops). Utilize existing system detectors, where available (e.g., Newport News) and develop interface to "download" data to TMS. For most areas, where little or no surveillance systems exist, develop field to TOC to TMS communications (processing in field). Detectors to be mid-block "system" detectors. CCTV to be located at selected locations based on congestion activity and level of accident activity (safety review)
Communication (Voice/Data/Video)	1-Provide Remote User Station Capability for Region's Transportation Agencies and Utilize Existing Fax/ Telephone/Modem/E-Mail Systems (Interim).	$5,000 per workstation	None	None	Year 1	Local Agency	Local Agency, CMAQ	Interim Plan as part of VDOT TMS. Uses existing communications capabilities, where feasible.
	1-Develop Communications Network Regionwide.	Variable	Limited	None	Year 1-5	Contractor	STP, VDOT, CMAQ, Public-Private Partnerships, Local Agency	Integral part of surveillance network Greater detail included with Initiative 3.
	2-Develop Information Exchange Network.	$5,000 per Workstation	None	Dedicated micro-computer meeting system needs	Year 2-3	Contractor, VDOT, Local Agency	STP, VDOT, CMAQ, Public-Private Partnerships, Local Agency	Costs may vary depending on planned functions of IEN
Information Processing	1-Develop Manual Input to Clearinghouse for Regional/Data (Interim).	$50,000	1 Technician & part-time staff (on demand)	None	Year 1 (Continuous)	Software development by contractor	STP, VDOT, CMAQ	Interim step till agencies develop remote access "download" ability.

Exhibit 11 (Cont'd)
COMPARE Implementation Plan

Function	Implementation Level - Activity	Estimated Cost ($)	Added Personnel Requirements	Added Equip. Requirements	Implementation Time (Period)	Means of Implementation	Funding Source	Institutional Issues/Interim Actions/Other Comments
Information Processing (Cont'd)	1-Expand VDOT TMS to Meet Regional Architecture System.	$50,000 (Variable)	None	Workstation for regional access (tied to planned system)	Year 1-2	Software development by contractor	STP, VDOT, CMAQ, Public-Private Partnership, Local Agency	Cost includes software development/revisions and remote workstation (for regional use) in TMS Center
	1-Upgrade and Automate VDOT/Regional TMS System.	$100,000	None	None	Year 1-2	Software development by contractor	STP, VDOT, CMAQ	Long-Term needs to be met also.
Traveler Interface Systems (TIS)	1-Implement VMS at Major Freeway-to-Freeway Points and Key Arterials to and from the North Carolina Border Area	$825,000	2 Maintenance Staff	15 Permanent VMS Spare Parts	Year 1-2	Contractor	STP, VDOT, CMAQ, Public-Private Partnerships	Coordinate with regional TMS plans. A portion of this program along I-64 near I-664 is contracted by VDOT. VMS placed in advance ≈¾mile of several major freeway-to-freeway connectors.
	1-Upgrade Phone-Based "1-800" Traveler Information System Regionwide.	N/A	None	None	Year 1-3	VDOT/Telephone Company	Public-Private Partnerships	May be activated by voice (telephone) or modem and return communication by voice/data/graphic. Format to be user-friendly (e.g., travel time-related).
	1-Promote Commercial TV Usage for Traveler Information Purposes	N/A	None	None	Year 1	Contractor/TV Stations	Public-Private Partnerships	Can develop teletext message on TV screen for commercial or cable TV.
	½-Implement HAR Regionwide and Upgrade to AHAR.	$480,000	None	AHAR units Spare Parts	Year 1-2	Contractor	Existing VDOT funds may be committed	VDOT currently plans to implement HAR regionwide. Upgrade to AHAR following initial implementation.
	2-Implement Interactive Kiosks at Major Public Generators and Key Arterials to and from the North Carolina Border Area.	N/A	None (private funding)	Approx. 34 Kiosk stations Spare parts	Year 2-5	Contractor	Public-Private Partnerships, Local Agency, Other Public agency (FDA, etc.)	Costs are for base system, communicating information from VDOT/regional TMS. Information to be primarily directed for Traffic/Traveler Information. Expansion capability.
Traffic Control and Management	2-Expand Existing Signal Systems (includes adding signal system for Williamsburg) Regionwide.	$4,500,000	2 Persons (Williamsburg); other staff--existing	Signal system (Williamsburg); new controllers/Master/ communication/ etc. existing closed loop systems	Year 2-5	Contractor/Local Agency	STP, VDOT, CMAQ, Local agency, Public-Private Partnerships	Expand for control/monitor capability of signals. Systems to be closed loop or central control systems.

Exhibit 11 (Cont'd)
COMPARE Implementation Plan

Function	Implementation Level - Activity	Estimated Cost ($)	Added Personnel Requirements	Added Equip. Requirements	Implementation Time (Period)	Means of Implementation	Funding Source	Institutional Issues/Interim Actions/Other Comments
Traffic Control and Management (Cont'd)	2-Expand Number of Signal Timing Plans and Traffic Responsive Feature for Signal Systems Regionwide	$500,000	None	None	Year 2-3	Contractor/Local Agency	STP, VDOT, CMAQ, Local agency Public-Private Partnerships	Expansions to be based on individual agency's needs.
	2-Expand Emergency Vehicle Preemption Systems Regionwide.	$1,200,000	None	EVP Units Spare Parts	Year 2-3	Contractor/Local Agency	Local agency, Public-Private Partnerships, Other public agencies (fire department, police, etc.)	Expansions to occur along selected regional corridors.
	1-Provide Signal Coordination/ Cooperation Across Jurisdictional Boundaries Regionwide.	Range: $50,000 - $100,000	None	None	Year 1-3	Contractor	STP, VDOT, CMAQ, Local agency, Public-Private Partnerships	Requires significant coordination and cooperation between adjacent jurisdictions. Timing plans with common cycle length and time base required.
	1-Implement Automated Incident Detection Algorithms for Interstates.	$100,000	None	None	Year 1-2	Software development by contractor	VDOT, CMAQ, Public-Private Partnerships	California-based algorithm proposed by VDOT.
	1-Computerized Incident Response Lists for Regionwide Application.	N/A	N/A	N/A	Year 1	Local Agency/VDOT	N/A	Part of traffic database features of TMS.
	2-Develop CAD for Emergency Response of Highway Incidents Regionwide.	$50,000	None	None	Year 2-3	Software development by contractor	VDOT, Local agency, Public-Private Partnerships	Cost includes software development; communication costs assumed to be a private venture.
	2-Automated Regional Traffic Diversion Plans.	$300,000	None	None	Year 3-4	Contractor/VDOT	STP, VDOT, CMAQ, Public-Private partnerships, Local Agency	Requires CADD and GIS to be in place (assumed part of TMS plan).

Exhibit 11 (Cont'd)
COMPARE Implementation Plan

B. Long-Term Projects

Function	Implementation Level-Activity	Estimated Cost ($)	Added Personnel Requirements	Added Equip. Requirements	Implementation Time (Period)	Means of Implementation	Funding Source	Institutional Issues/Interim Actions/Other Comments
Surveillance	3-Extend CCTV Coverage along Regional/Arterial Highway System (est. 10 sites/year).	$400,000 per year	Maintenance staff (dependent on level of CCTV by agency)	CCTV	Year 6-10	Contractor	STP, VDOT, CMAQ, Public-Private Partnership, Local Agency	Sites to be selected in mid-Term based on regional needs at the time
	3-Extend Weather/ Environmental Sensor Coverage along Regional/ Arterial (est. 4 sites/year) Highway System.	$120,000 per year	None	Weather/ environmental sensors	Year 6-10	Contractor	STP, VDOT, CMAQ, Public-Private partnership, Local Agency, Operational Test (with new technology)	Sites to be selected in mid-Term based on regional needs at the time
	3-Implement Transit AVI/AVL System for PenTran and TRT and AVL System for Emergency Vehicles Regionwide.	$2,500,000	3 Maintenance staff/agency	Computer workstation (one/agency), GPS system, AVI/AVL detectors	Year 6-7	Contractor/Transit Agency/Emergency Vehicle Operation	STP, VDOT, CMAQ, Public-Private Partnership, Transit Funds, Local Agency	Costs of systems may vary depending on system applications. Monitor James City County transit system (if necessary, provide AVI/AVL capabilities)
Communications (Voice/Data/ Video)	3/4-Enhance Information Exchange Network.	$250,000	None	None	Year 6-10	Software development by Contractor	STP, VDOT, CMAQ, Public-Private Partnership, Local Agency	Enhance data display and information processing capabilities
	3-Provide Video Conferencing for Region's Transportation Agencies.	$20,000/ agency sites and $75,000 software development`	None	Video camera at agency site(s)	Year 6	Contractor/Local Agency	Local Agency, CMAQ, Public-Private Partnership	Based on agencies' needs
	3/4-Area Expansion to Other Districts, etc.	$5,000/ workstation	None	Year 6-10	Dedicated microcomputer meeting system needs	Contractor/Agency	VDOT, Public-Private Partnership, Agencies	Costs to be bred by agency desiring IEN capability/network

Exhibit 11 (Cont'd)
COMPARE Implementation Plan

Function	Implementation Level-Activity	Estimated Cost ($)	Added Personnel Requirements	Added Equip. Requirements	Implementation Time (Period)	Means of Implementation	Funding Source	Institutional Issues/Interim Actions/Other Comments
Traveler Interface Systems	3-Implement Interactive Kiosks at Major Generators.	N/A	None (private funding)	Kiosk stations Spare parts	Year 6-10	Contractor	Private funds	Sites to be selected in mid-Term based on private and regional needs.
	3/4-Implement VMS at Major Freeway Diversion Points and at Key Arterial Decision Points.	$4,290,000	6 Maintenance staff	78 Permanent VMS, Spare parts	Year 6-10	Contractor	STP, VDOT, CMAQ, Public-Private Partnership, Local Agency	Coordinate with regional TMS plans. VMS may be superceded by a new technology providing high-level, En-Route guidance (where developed and tested by mid-Term)
Traffic Control and Management	3-Expand Signal Systems as New-Signals are Installed (est. 30 intersections/year) Regionwide.	$450,000	Maintenance staff (dependent on level of ATMS by agency)	New controllers for system control	Year 6-10	Contractor/local agency	Local Agency, CMAQ, VDOT	Expansions to be based on system control needs.
	3-Provide Greater Signal Coordination Cooperation Across Jurisdictions/ Boundaries Regionwide.	Range: $20,000 - $50,000/Year	None	None	Year 6-10 (as needed)	Contractor/Local Agency	STP, VDOT, CMAQ, Local Agency, Public-Private Partnership	Extends/enhances existing, system as local agencies systems and area growth occurs.
	3/4- Implement Automated Incident Detection Algorithm for Regional Arterial Network	$200,000	None	None	Year 6-7	Software development by Contractor	VDOT, CMAQ, Public-Private Partnership	New concept/algorithm to be tested and/or developed. No current reliable algorithms exist.
	3/4-Implement Automated, Real-Time Traffic Diversion Algorithm.	$350,000	None	None	Year 6-7	Software development by Contractor	STP, VDOT, CMAQ, Public-Private Partnership, Local Agency	Requires interaction/communications with regional clearinghouse for real-time traffic data.
	3-Implement Regionwide Ramp Metering (Staged)	$7,550,000	4 Maintenance staff	Ramp Controls, Signal display equipment, Detection system	Year 6-10	Contractor	STP, VDOT, CMAQ, Public-Private Partnership	Stage 1 - Route 44; I-64, from south of HRBT to Route 44; I-264, from I-64 to east of Portsmouth Stage 2 - I-64, from Route 44 to I-464; I-464; I-264, from I-664 thru Portsmouth; I-64, from HRBT to Mercury Blvd. Stage 3 - I-64, from I-464 to I-664; I-664; I-64, from Mercury Blvd. To north of Williamsburg area.

VDOT has established a framework for public transportation agencies to collaborate and cooperate with private entities through the Public-Private Transportation Act of 1995.

RESOURCE REQUIREMENTS

The estimated cost of each of the activities has been developed based on unit costs for similar installations and on the quantities suggested by coverage described and mapped earlier. In some cases, the specific equipment assumptions are provided as "added equipment requirements". Given the continuing deployment activities of VDOT, the boundaries between "existing conditions" and the items to be deployed (as recommended herein) are continually changing. At the same time, the costs of much of the technology (as well as the appropriate technology selections themselves) are evolving rapidly. All cost factors must be considered on the basis of an "order-of magnitude" only.

It is apparent that the major public capital costs are related to surveillance requirements, which, it should be noted, also includes the major communication costs of connecting field devices with the TMS system and the interagency communications lines as well. Such costs are increasingly incorporated into larger construction or reconstruction projects as provision of ITS infrastructure becomes standard operating procedure. Other higher cost items include the expansion of traffic control.

The ITS has also introduced important staffing implications These have been estimated in terms of maintenance staff as well as operational staff rather than dollar costs. Clearinghouse operations are presumed to be conducted with existing staff after development and start up. Either or both of these staff requirements can be implemented through in-house staff development or privatization.

IMPLEMENTATION

Exhibit 11 includes an indication of priorities for staging implementation. Levels 1-4 have been indicated to describe the programming and packaging on a priority basis with Level 1

- Supporting regional interagency approach (remote user workstations)
- Immediately visible User Services (cable TV, upgraded l-800 information)
- High leverage/low cost actions (computerized incident response)

Short Term Level 1 activities are indicated for implementation starting in year 1 with varying lengths for completion based on an estimate of the impact of both capital requirements and institutional relationship and procedures development. As a result, some of the more complex high priority activities may take 2-5 years to complete, which provides an additional rationale for early start-up. Level 2 activities should follow Level 1 within the Short-Term plan. The Long-Term plan items have been staged from years 6-10.

Overall, the order indicated should provide a rough "path" for an evolutionary implementation that is cost-effective and supportive of a regional interagency approach and generating public awareness and support.

IMMEDIATE ACTION

A key challenge facing COMPARE is the transition from "study" to implementation. To aid in this transition, the COMPARE Technical Committee has formed three Task Forces -- Institutional/Financial, Public/Private Partnership, and Technical Systems Interface -- to identify key implementation issues, prioritize those issues and begin to develop consensus on the appropriate immediate actions to "institutionalize" the COMPARE program. Key action items will include:

- Institutional/Financial issues
  - Formally establish the ITS Subcommittee of the HRPDC Technical Committee as the Policy entity to guide the regional and/or cooperative aspects of the COMPARE program and establish regular meeting schedules.
  - Secure appropriate representation from appropriate divisions of VDOT to ensure continuation of the COMPARE program.
  - Brief chief administrative officers and elected officials on the general program consensus.
  - Review priorities for budget implications and establish a procedure to consider common needs while dealing with the problem of uneven resource availability among COMPARE agencies.
  - Establish interim staff support (donated staff, rotating responsibility) for convening, agenda-setting and follow up.

- Technical Interface
  - Establish initial Regional Clearinghouse functional procedures regarding network focus, threshold issues, shared data definitions and communication procedures.
  - Consider appropriate stages for establishing and upgrading an interagency communication network, starting with the existing electronic bulletin board function planned as part of VDOT TMS and upgrading as appropriate.
  - Complete current program of developing incident response protocols and diversion plans.
  - Consider ownership and maintenance responsibilities of common system infrastructure.
  - Determine procedure for cross-boundary/interjurisdictional coordination and common technology selection.
  - Review current VDOT TMS development schedule and current commitments for surveillance and communications and develop detailed budget, roles and critical path for Level 1 activities of the Operations Plan.

- Public/Private Partnerships
  - Consider suitability for and barriers offered by current VDOT public/private partnership program for communications systems resource-sharing, value-added information service provision and other types of collaboration that may be pertinent to COMPARE.
  - Solicit private sector interest from media and service providers regarding radio, TV and dial-up services (secure staff support to carry out this activity).
  - Review options for contractual arrangement with partnerships.

These and other issues will provide a substantial agenda for the new HRPDC ITS and Operations Subcommittee.